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MEMOIRS
OF
THE GEOLOGICAL SURVEY OF INDIA.

Palæontologia Indica,

BEING

FIGURES AND DESCRIPTIONS OF THE ORGANIC REMAINS PROCURED DURING THE PROGRESS OF THE GEOLOGICAL SURVEY OF INDIA.

PUBLISHED BY ORDER OF HIS EXCELLENCY THE GOVERNOR GENERAL OF INDIA IN COUNCIL.

Ser. XIII. SALT-RANGE FOSSILS,

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I. PRODUCTUS-LIMESTONE FOSSILS:

iv. (fas. 5.) BRACHIOPODA.

WITH PLATES LXXXII—LXXXVI.

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IV.—Sub-order: CORALLIOPSIDA.

Family: *RICHTHOFENIDÆ.*

I create this sub-order, as well as this family, to contain a single genus, *Richthofenia*, Kays., a fossil which exhibits such strange and conflicting characters that I am in doubt whether even the prominence I give to it, in creating a distinct sub-order for it, will be sufficient to bring out the quite separate position it holds, not only among the *Brachiopoda*, but also among the whole of the mollusca and molluscoids.

In the Records of the Geological Survey of India, Vol. XVI, part 1, 1883, I have given a preliminary description of these fossils, and in that paper I came to the conclusion that we had to deal with a form of shells more or less related to the *Brachiopoda*, but showing at the same time many characters which are generally found in corals, and exhibiting, moreover, some peculiarities which recall to a certain extent the *Rudista*. Ever since the publication of that paper I have continued my studies on these fossils; and though in the general structure of the shells little that was new remained to be ascertained, there was the microscopic structure of the shell-substance to be studied more in detail; this has not, however, resulted in a clearer elucidation of the systematic position of these animals.

After prolonged and very careful reconsideration of all the facts relating to these fossils, I have come to the conclusion that the probability is strongest in favour of their being *Brachiopoda;* and that if this be the case, they have to be placed in the vicinity of the *Productidæ*, at the end of the *Arthropomata*. My reasons for this course were the following:—

The question is reduced to a simple alternative, either these fossils are *Brachiopoda* or they are corals; the third position hinted at in my former paper, as to whether they might not belong to the *Rudista*, is no longer to be considered, as my appeal to the scientific public on this account has met with no response. The point should not, however, be wholly lost sight of.

Now, as regards placing these fossils among the corals, the reasons to be adduced against such a decision are numerous: First, there is the very vivid silky lustre of the shell, a thing which but very rarely and never in this degree occurs in corals. Then the three vertical septa of the larger valve have a rather median position, forming a kind of columella, and have no connection whatever with the outer walls of the shell, so that they can only be made visible by a section, and never by etching away with acid the epitheka, or any such structure, as can generally be done with corals; and I have never seen a coral with the septa restricted exclusively to the columella, and totally absent beyond it. A third point of discrepancy consists in the hingeline, which is straight and smooth, without the slightest trace of denticulation,—a hingeline which never occurs in this form in an operculated coral. A fourth strange character is the existence of a distinct pallial impression along the upper margin of the larger valve. But what overrules all the other points is the existence of muscular impressions in both valves, as will be described further on. As against these characters in which they deviate from corals, we find only the general conical outline, the root-like hollow processes protruding from the surface of the larger valve at irregular distances, and a cellular structure of the median shell-layer in connection with numerous partitions or tabulæ filling the lower part of the same valve; characters which occur also in the rugose corals. These are not, however, of very material importance: the more or less regular conical form is only an apparent one, as I shall have occasion to show presently; the root-like appendages occur as well in species of *Productus*; and even the cellular structure and the partitions occur in such strangely developed forms of Brachiopods as *Prod. proboscidens*, as has been kindly communicated to me by Prof. Lindström, no sufficiently well-preserved specimens of that species being at my disposal for dissection. Thus we see that the peculiarities by which the *Richthofeniæ* seem to be linked more or less closely to the corals, are not exclusively restricted to that latter class of animals, but occur also in known aberrant forms of the *Brachiopoda*.

As regards the placing of the *Richthofeniæ* in the *Brachiopoda*, several reasons can be adduced in favour of it. First of all the silky lustre of the shell resembles exactly that occurring in *Productus* and allied genera; then the fine punctation of the shell is also exactly like that of *Productus*. For other similarities we must examine each valve separately. The smaller valve is hemmed in at its upper end by a not very long straight hingeline, which is interrupted in the middle by a prominent knob composed of two short elevated ridges, which are either parallel or converge somewhat in one or the other direction. The knob is limited on both sides by somewhat sloping triangular shelly faces extending between the knob and the lateral terminations of the hingeline. The median prominent knob may well be taken as a kind of cardinal process, which fits into a semi-circular emargination of the hingeline of the other valve. This emargination is bridged over by a vaulted shelly piece corresponding exactly to the pseudodeltidium of *Strophalosia* or *Aulosteges*. This pseudodeltidium does not, however, show externally on the larger valve, but appears only when the rather thick shell is broken away, and a partial internal cast is produced. Then also a kind of area appears, in the middle of which the pseudodeltidium is situated; it begins at the apex of the valve and extends down to the hingeline, corresponding in breadth to the length of that line. The homology of these shell-parts with the corresponding parts of the *Brachiopoda* was first pointed out to me by Prof. Lindström; but there remains the difficulty, that these parts do not show outside the larger valve, but only appear when the greater part of the shell is broken away and only the innermost coating remains. To understand this we must study the shell-structure in the larger valve. When we examine that part where the margins of the two valves touch each other, we find that the smaller valve is sunk into the large one, and that the margins of the latter extend far above and beyond the smaller valve. These projecting parts of the larger valve were secreted by a rather moveable fringe of the mantle of the animal, which did not deposit one shell layer above the other quite regularly, but in the most irregular way became vaulted and wavy in all directions, so causing the formation of innumerable more or less hemispherical cells in the median shell-layer; only in the outer wall of the shell did it form again a continuous shelly deposit. This mantle-fringe was not restricted to the frontal and lateral parts of the animal, but protruded also over the hingeline, forming outside of it the same cellular layer as on the other parts of the shell, and thus the forms of the area and pseudodeltidium were quite obliterated on the outer surface of the shell. From these considerations it would appear that we must take the partial internal cast (Plate LXXXIII, fig. 15) as representing the real shape of the shell, and the outer form of the specimens as produced by an exuberant growth of the shell-substance.

In intimate connection with the above peculiarity in the growth of the shell is the existence of a chambered lower part in the larger valve. This valve seems to grow in length more rapidly than the animal augments in size, and thus the animal is forced to chamber off those parts of the valve which it cannot fill with its body.

The next point which requires consideration in connection with the Brachiopod nature of these fossils is the muscular impressions. In the smaller valve we have two large muscular impressions on both sides of the middle line, not far from the hinge-margin and the cardinal process. These impressions, with their many roundish emarginations along the upper and outer borders, have, it must be confessed, not much similarity to the muscular impressions of other *Brachiopoda*. That they are, however, really muscular impressions, appears highly probable from a consideration of the other valve.

In my note on the genus *Richthofenia* in the "Records," I described the median septum of the larger valve, and added that from this septum on both sides some low secondary septa originate, showing on the whole a pinnate arrangement. Some preparations subsequently made have shown me that we have not to deal here with secondary septa, but with deep emarginations of a muscular impression of exactly the same pattern as the one on the smaller valve. But the impression only just touches the bottom of the valve with its lower margin and extends for the greater part up the lateral face of the septum, so that the septum itself with its two lateral faces serves for the support of a pair of muscles, which must be taken as adductors, according to the placement of the impressions of the same muscles in the smaller valve.

Beyond and somewhat below these impressions, on the inner side of the two lateral septa, the deep pocket-shaped grooves are situated, as described in my former note. These deep grooves must probably also be taken as muscular impressions, and they can only be the pair of (anterior) divaricators, extending from the grooves up to what was described above as a sort of cardinal process.

The septa themselves have, so far as I am aware, no analogue whatever in other Brachiopoda; their presence also must probably be explained through the excessive growth of the larger valve, to which cause all the other peculiarities have been attributed. To make sure of all these points, it would be necessary to examine quite young specimens of these fossils. I think it should not be difficult to find such; but I regret to say that there are none among the materials at my disposal. Thus my deductions must remain to a certain extent conjectural and uncertain.

To recapitulate what has been said on the relations between the *Brachiopoda* and the *Richthofeniæ;* we have seen that in the smaller valve there exists a kind of cardinal process, a straight not denticulated hingeline, and very large muscular impressions on both sides of a well-developed, sometimes bipartite, median septum. In the large valve we have also a straight hingeline, which is interrupted in the middle by a kind of pseudodeltidium. This latter is situated in the middle of something like an area, and extends to the apex of the valve. In the interior the adductor impressions are situated on the lateral faces of a short median septum, and the divaricators are inserted in deep pocket-shaped grooves situated outside and in front of the adductors. If, then, all these interpretations of the different parts are correct, there can be but little doubt that the fossils bearing these characters must be considered as *Brachiopoda;* and they must moreover, on account of the position of the muscular impressions, be placed in the order *Arthropomata.*

From the same considerations and interpretations, the degree of affinity of these fossils to the different groups of the *Brachiopoda*, and to other classes of the molluscs and molluscoids, may be judged. Though there cannot be any doubt that the *Richthofeniæ* form part of the *Arthropomata*, yet the difference from other forms of this order is very great indeed. Already the external shape is very extraordinary, and not like that of any other Brachiopod. There is, as far as I am aware, no case known up to the present in which the area and pseudodeltidium is entirely covered up by an excessive growth of the shell, or in which the smaller valve is sunk in so deeply into the larger one. The shell-structure of the larger valve seems also very unusual, though, by Dr. Lindström's discovery of a similar structure in *Prod. proboscidens*, this feature is no longer so peculiar. The muscular apparatus of the *Richthofeniæ* is far more abnormal. In the smaller valve only one pair of very large impressions with a strangely indented outline is observable, while in the other valve there exist two pairs of impressions, one pair for the adductors, another for the divaricators, as in other *Brachiopoda.* The position of these impressions is, however, very peculiar. The adductor impressions are situated on the lateral faces of a prominent median septum, and the divaricator impressions are sunk in deep narrow pocket-shaped grooves, having their faces probably turned laterally and not horizontally. Of a brachial apparatus, properly speaking, nothing exists in these shells, unless the three upright septa in the middle of the larger valve should possibly be compared to the median prominence in *Crania* and allied genera, which latter organ also serves for the support of the brachial apparatus.

If all these peculiarities indicate already a very great difference between the *Richthofeniæ* and the other *Brachiopoda,* there are some other characters which make this difference far more apparent. In speaking of the characters of the smaller valve, I mentioned that on both sides of the cardinal process between it and the hingeline there extended sloping, triangular, smooth faces. These faces might very well have served for the insertion of a ligament; but after all that has been said on this point in the description of the genera *Aulosteges* and *Productus*, it would not be very perplexing if a ligament had existed in the *Richthofeniæ*. By far more strange is the existence of a pallial impression in the *Richthofeniæ*,—a character which has, as far as I am aware, not yet been described in any Brachiopod, except, perhaps, in *Thecidea* and *Crania*. This pallial impression is to be found immediately below the prominent margin on which the smaller valve rests. It is composed of a series of furrows, all parallel to the margin, and occupying together a breadth of about 5 mm. These furrows are, however, absent below the hingeline. It is hardly possible to suppress the opinion that we have here really to deal with a pallial impression. There is further another very perplexing fact in the emarginated condition of the adductor impressions in both valves. I know of no Brachiopod in which such impressions occur; but in *Pelecypoda*, they may exceptionally be observed. If, for instance, we examine attentively old specimens of living species of *Spondylus*, we find very distinctly emarginated muscular impressions not dissimilar to the impressions of *Richthofenia;* the muscular impressions of the true *Rudista* are also not quite dissimilar.

To sum up all that has been said on the affinities of the *Richthofeniæ*, we have found that these shells most probably belong to the *Brachiopoda*, but that they constitute so strange a group within this class, that though they may be assignable to the *Arthropomata*, yet they cannot be placed immediately in the vicinity of any known group. They show on the one hand external affinites to the corals, and on the other structural affinities to the *Pelecypoda*. This conflicting evidence alone will justify my considering them at least as a proper sub-order, for which I introduce the name of "*Coralliopsida*."

Prof. Kayser, in his description of these fossils in Richthofen's "China," thinks it most probable that they should be brought into connection with the *Craniadæ*. Though this cannot be done on account of the position of the muscular impressions as described above, yet I must confess that I am myself also much inclined to consider these forms as to a certain extent transitional between the *Arthropomata* as a whole and the *Craniadæ*.

We shall see in the description of the *Craniadæ* occurring in the Salt-range, that there existed forms which make such a transition yet more probable.

Genus: RICHTHOFENIA, Kayser.

After a careful study of all the available materials of these fossils, it is considerably more easy to give a characteristic of them; the characters of the genus may now be framed in the following manner:

The shell is composed of two valves, one smaller and one larger. The smaller valve is entirely flat or even concave; the larger valve is elevated, conical, and very irregular in its outline. Thus the general shape of the shell is irregularly conical, showing at the same time a more or less circular transverse section.

This general shape is, however, only a distorted one, caused by an excessive growth of the large valve, by which certain characters of the outline are covered up, and are not observable in the intact shell.

The two valves articulate in a straight hingeline, sometimes very short, sometimes somewhat longer, interrupted in the middle by a prominent cardinal process in the smaller, and by a small semi-circular emargination, covered by a kind of pseudodeltidium in the larger valve.

The circumferential outline in the two valves is thus very different. The smaller valve is limited on the one side by the straight hingeline, which is followed laterally by rather deep emarginations, while the lateral and frontal margins are well rounded, forming together a transversely oval outline. In the larger valve, on the contrary, though the straight hingeline exists, and also laterally two thickened parts fitting into the emarginations of the other valve, yet the circumferential outline is circular or transversely oval, and none of these parts show externally on the valve, but appear only when the large part due to the exuberant growth of the shell-substance is removed. Then one can observe that the straight hingeline corresponds to a flattened area extending to the apex of the conical valve, and in the middle of which a vaulted pseudodeltidium is placed. In the Indian species of *Richthofenia* this pseudodeltidium is narrow in comparison to the breadth of the area, while it is very broad in the Chinese species. On both sides of the area there extend deep impressions, which are filled with the thickened shell when complete. The remainder of the valve shows a more or less circular or transversely oval outline, often with a low indentation opposite the hingeline.

The external appearance of the two valves is also very different. In the smaller valve the external surface shows a fine granulation, between which can be observed very fine concentric striæ of growth. In the surface of the larger valve two regions are distinguishable. The first region is that turned to the outside of the valve. It is covered by a great many irregular concentric wrinkles, which are from distance to distance drawn out into prominent points, through which hollow, root-like, tortuous spines proceed. Sometimes a very fine longitudinal striation can also be observed on this surface. The cause of this striation can be seen when the outermost layer of the shell is removed. Then a very fine punctation appears, which is sometimes arranged in approximately vertical rows, by which arrangement the striation is produced. The second region of the surface of the larger valve is that at the upper end. This valve does not terminate where it is met by the other valve, but extends often considerably in advance of it, either vertically or laterally. The internal surface of this extended part of the valve shows the same fine granulation as that covering the external surface of the smaller valve. The valve is fastened by the apex as well as by the root-like spines to foreign bodies.

The substance of the shell in both valves has a dull silky lustre when entirely preserved; and this lustre is very vivid when the outermost layer of the shell is removed. Then, also, a fine punctation appears, in which, among the numerous very fine punctures, some larger ones are disseminated.

Such are the external characters of the genus. The internal characters are only very imperfectly known in the Chinese species, and I shall only introduce into the characteristic of the genus those features which are known to exist in the Chinese as well as in the Indian shells.

In the smaller valve the cardinal process bears a pair of short, prominent ridges which fit into the cavity of the pseudodeltidium. In front of these a low but distinct median septum extends nearly to the front of the valve; it is sometimes bifid towards the hingeline. On each side of this septum in the Indian species, there is a large muscular impression.

In the larger valve the median part is occupied by three short, upright septa, which may perhaps correspond to the nose-like process in the middle of the valve of *Crania*; in the vicinity of it two pairs of muscular impressions are situated. The lower part of the valve is chambered off by many partitions, through which the septa extend vertically. The bottom of the uppermost chamber in which the animal lived is very uneven. The lateral parts form deeply hollowed grooves, whilst from the hingeline to the septa there extends a sloping plane, and from the septa to the front a more or less broad, rounded, elevated saddle is observable. The whole internal surface of this valve is covered with small, prominent, roundish tubercles and some granulations. From the outer walls of theanimal chamber short vertically-placed ribs project towards the interior at irregular distances, bearing at their upper termination the entrances to the hollow, tortuous, root-like spines, which have been described above.

These characters will suffice to recognise the genus under all circumstances. The affinities of the genus have been discussed in the introduction to the family, and thus there remain only some words to be said about the species contained in the genus.

The genus was founded by Prof. Dr. E. Kayser, on two specimens collected by Baron von Richthofen at Lo-Ping in China, and which were identified by Prof. Kayser with the fossil that had been formerly described by Mons. de Koninck from the Salt-range under the name of *Anomia lawrenciana*. Owing to the great liberality of Geheimrath Beyrich at Berlin, I am in a position to make a close comparison of the Chinese fossils with the Indian ones, as he with great kindness sent me these two very precious specimens for further study.

From this comparison it now appears with certainty that the Chinese fossils, though beyond doubt generically identical with *Anomia lawrenciana*, belong to a different species, for which I wish to introduce the name of *Richthofenia sinensis*, Waagen. It differs from the true *Richth. lawrenciana* by the very short hingeline, and the larger cardinal process in the smaller valve. The median cystoid shell-layer is also much less strongly developed, and the partitions in the apical part of the larger valve have a different shape in the Chinese fossils, so that it cannot be subject to any doubt that *Richt. sinensis* is a species different from *Richt. lawrenciana*.

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As regards the geological and geographical distribution of the genus, it has up to the present been detected only in upper palæozoic beds of China and India. In the former country it occurs in undoubtedly upper carboniferous deposits, whilst in India it extends through the whole Productus-limestone, thus probably reaching the permean age.

1. RICHTHOFENIA LAWRENCIANA, Koninck, sp., Pl. LXXXII, fig. 1, LXXXII A and LXXXIII.

1863. *Anomia lawrenciana*., Koninck : Quart. Journ., Geol. Soc., Lond. vol. XIX, p. 6, pl. IV, figs. 7, 8, 9.
1863. *Anomia lawrenciana*, Koninck : Foss. paleoz. de l'Inde, p. 18, pl. III, figs. 7, 8, 9.
1881. *Richthofenia lawrenciana* (Koninck, sp.), Kayser : Zeitschr. d. Deutsch. Geolog. Ges., vol. XXXIII, p. 351, (pars).
1882. *Anomia* (*Richthofenia*) *lawrenciana* (Kon. sp.), Waagen : Neu. Jahrb. f. Min., 1882, vol. I, p. 115.
1883. *Richthofenia lawrenciana* (Kon.), Waagen : Records, Geol. Surv. of India, vol. XVI, part I, p. 12, pls. I. II.
1883. *Richthofenia lawrenciana* (Kon.), Lindström : Richthofen's China, vol. IV, p. 74.
1883. *Richthofenia lawrenciana* (Kon.), Kayser: Richthofen's China, vol. IV, p. 195 (pars.: quotations from India), pl. XXIV, figs. 6, 7, 8 (non 4, 5).

Already Mons. de Koninck, in describing this very strange fossil in 1863, remarked that it was among the most interesting that were brought by Dr. Fleming from India, and that though in its general appearance more similar to an *Anomia*, yet by the occurrence of spines on the larger valve it to a certain extent resembled *Productus*, and thus in these few sentences the whole difficulty encountered in the classification of this fossil was already foreshadowed.

Though I have described this fossil already somewhat in detail in the Records, yet I must here in great part repeat that description; on the one hand, because this monograph should be complete; on the other, because I have since then learned to understand more clearly several points in the structure of the fossil, and thus the description will have to be completed and corrected in several points.

The fossil consists of two valves, one larger and one smaller. The larger is of an elevated conical shape, with the apex fastened to some foreign body. The smaller valve is flat, more or less sunk into the larger one. The two valves articulate by a not very short hingeline, which, however, does not appear in the outer aspect the conical valve; it is only marked inside it. At both ends of the hingeline the smaller valve is cut out in a semicircle to receive thickened parts of the shell of the larger valve. The outer side of the larger valve is rugose, provided with many concentric wrinkles and bears a variable number of hollow, depressed, diverging, tortuous tubes, which, on the one hand, resemble the root-like appendages of some rugose corals, and on the other, can be compared to the hollow spines of some *Producti*; the resemblance to the latter is chiefly striking because of the silky lustre of the shell substance of which they are composed. On the whole, the shell of the fossil is rather dull when intact, and of a vivid silky lustre when the outermost layer of the shell is worn off. There also appears a very close punctation, similar to that occurring in the shell of *Productus*; it is barely visible to the naked eye.

The punctures are not all equal; some larger ones of two sizes are disseminated irregularly between great numbers of smaller ones. These punctures are sometimes arranged in tolerably regular vertical rows, and then even the outer shell-layer on which the punctures are not visible appears as if very finely striated longitudinally.

On the smaller (flat) valve the hollow tubes, which are so very characteristic of the larger valve, are altogether absent. When the shell substance of this valve is perfectly preserved, it is strewn over with very numerous small papillæ that project slightly from the surface of the shell. The same papillæ are to be found on the upper and inner face of that part of the large valve which projects beyond the smaller valve. We shall see in the description of the microscopical structure of the shell that these papillæ form the entrances to the little canals which pierce the shell substance of the large valve. It has not been possible to make microscopical sections of the smaller valve, but the presence of the same papillæ suggests the presence of the same canals in this valve also. On its interior side this smaller valve bears a distinct, but not very high, median septum, extending from near the margin opposite the hingeline nearly to the middle of the valve. Here it is often replaced by two parallel ridges, which in other specimens, however, are combined in one broader septum. On both sides of this septum large muscular impressions, more or less rounded, are very strongly marked and distinctly indented on the side nearest the hingeline; on the side opposite to it they are less strongly marked, but seem to be also indented. In the middle of the hingeline there are, vertical to it, two short and thick prominent more or less parallel ridges, not dissimilar to hingeteeth; they are, however, about equally high throughout. They are not in connection with the median septum, but are separated from it by a smooth space. They do not protrude much above the hingeline, but yet sufficiently so to be considered as forming together a kind of cardinal process. On the sides of these ridges no trace of dental grooves can be seen. Along the frontal or outer margin itself, not far distant from it, more or less numerous curved thorns occur, directed towards the interior of the shell, similar to those in some *Producti*.

The structure of the larger valve is far more complicated. It consists of two distinct parts; the lower, from the apex of the valve to about the middle of its height, being composed of very numerous narrow water-chambers divided off by very thin shelly partitions; and the upper, forming a large hollow for the reception of the animal. The partitions in the lower part of the shell are very irregular, on the whole convex below and concave above; not so, however, for their whole extent, as about in the middle they are bent upwards, forming something like a columella, as it is called in corals. This bending up is caused by three vertical septa, which extend from the apex of the shell through all the partitions up to the animal-chamber. These septa are narrow, upright, shelly lamellæ, of which the middle one commences not very far from the hingeline and is in direction perpendicular to that line, whilst the two lateral ones converge from both sides towards the frontal termination of the median one. In transverse sections of the valve it often appears as if a triangular space was entirely partitioned off from the remainder of the shell by these lateral septa in connection with the hingeline. This is, however, in reality not the case. The septa are in no connection whatever either with the hingeline, or with any other part of the outer wall of the shell; they are narrow, upright, shelly lamellæ, resembling somewhat the blade of a knife. The appearance as if they were in connection with the hingeline is only brought about by the partitions of the water-chambers, which in this region often ascend quite vertically, and can then only with difficulty be distinguished from the septa. The partitions extend between and around the septa, bent in various directions, up to the hingeline.

The animal-chamber is tolerably large; the bottom of it is, however, situated at very different levels. The space between the septa and the hingeline is much more shallow than the remainder of the chamber; but the latter also is not even, as from the centre of the shell a rounded crest extends to the wall opposite to the hingeline, forming a shallow saddle. On each side of this crest is a deep hollow, which occupies the whole lateral parts of the animal-chamber. The whole bottom is covered by an irregular, tolerably minute grooving.

The three vertical septa project into the animal-chamber as three high, upright plates, which converge towards the centre of the shell and are highest near this centre. The median one is highest and never curved in any way, but the lateral ones are often, or nearly always, concave on their inner and convex on their outer side. The upper margin of all three is crenulated. They never unite but remain always apart, though they approach each other very nearly in the centre. From their highest point they descend vertically to the bottom of the animal-chamber; on the other side, however, between them and the hingeline, there is an ascending plane, none of the septa reaching the hingeline. These septa seem to have served, to a certain extent at least, for the insertion of the muscles.

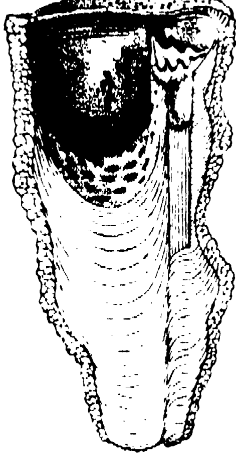

FIG. 24. RICHTHOFENIA LAWRENCIANA, Kon. Somewhat schematic section through the ventral valve from the hingeline to the front, showing the animal-chamber and the partitions below. In the former, the upright median septum is observable, with the emarginated muscular impression on its lateral face. The pocket-shaped groove for the reception of the divaricator is cut open. The lateral septum, with its vertical striation, is exposed below it.

On both sides of the median séptum, and extending up the lateral planes of this septum, there are large muscular impressions exactly of the pattern of the impressions of the other valve; these are deeply indented on their lower side, and have on the whole a somewhat roundish triangular shape. The indentations reach often far up the lateral faces of the septum. The two lateral septa are limited on their inner side by deep pocket-shaped grooves, in which probably also the insertion of muscles took place. The place of insertion was probably the septum itself, as, in several specimens, I found that the inner side of these septa showed irregular thickenings, probably produced by muscular insertions. The outer sides of the lateral septa are provided with a very fine longitudinal striation.

The hingeline is quite straight and smooth, and shows only in the middle a slight rounded sinuation for the reception of the cardinal process of the other valve.

The inner side of the outer walls of the animal-chamber, as well as the inside of the outer walls of the larger valve in general, is provided at very irregular and unequal distances with tolerably broad and sharp, but not very prominent, vertical ridges, some of which begin a short distance below the upper border of the animal-chamber, and disappear before reaching the bottom; while others begin lower down, and then reach to the bottom and extend even below it. The upper termination of each of these ridges bears a rounded foramen, which forms the entrance to the hollow root-like tubes which can be observed on the outer side of the shell, as has been described above. This foramen, however, does not pierce the wall directly, but the tube descends nearly vertically and appears at the outer side of the shell only in the vicinity of the apex.

All round the upper border of the animal-chamber, but a good distance below the margin of the valve, a thickened prominent ledge occurs, below which again a number of impressions parallel to the margins can be observed. The whole seems to be exactly comparable to a pallial impression.

The substance of the shell is of a very singular structure. It is composed in the larger conical valve of the three layers. The outer one is very thin, dull, and compact outside, and of a silky lustre inside, provided with the characteristic punctation and striation mentioned above. The median layer, the thickest of all, though very irregular in its thickness, is composed of approximately hemispherical cysts, arranged very irregularly and interrupted at intervals by perfectly straight, radial, very pointedly conical, thin shelly tubes, which apparently are most numerous in the thickened shelly parts at both ends of the hingeline, and which require further explanation. They begin at the outer shell-layer with a slightly broader base, and extend in a more or less ascending direction towards the inner portions of the shell. They appear more or less polygonal in the transverse section. All do not with their sharply pointed ends reach the innermost shell-layers; indeed most of them stop about half way. Nor do all of them originate from the outer shell-layer, for some start from the wall of some cyst in the median layer of the shell. They form, as has been said above, very thin tubes, which apparently communicate with the larger pores disseminated between the more minute punctation of the shell as described above. The much larger hollow tubes terminating in the root-like processes, penetrate this median part of the shell substance in a nearly vertical direction. The innermost layer of the shell is somewhat thicker than the outer one, but otherwise similar to it. The median and outer layers of the shell fall off easily, and then internal casts of strange description are produced, which preserve the inner shell-layer. It has been said in the discussion of the systematic position of these fossils, that of all the teguments which can be distinguished in this larger valve, probably this inner shell-layer is the essential part, from which the real shape of the valve must be judged, and that the other layers, the median as well the outer one, are probably due only to an exuberant growth of the shell.

In the flat smaller valve the median shell-layer is absent.

Under the microscope many other features of the shell-structure can be observed. It then appears very clearly that the shell of the larger valve is composed of a great number of very thin lamellæ, closely packed together in the innermost and in the outer shell-layers. These lamellæ disunite on the one hand towards the interior of the shell to form the partitions with which the lower part of the valve is filled, and on the other hand for the formation of the cysts of the median shell-layer. The lamellæ are mostly more or less vertical in the inner shell-layer, then bend outward in a somewhat horizontal direction, but very irregularly, disuniting and again re-uniting and thus forming the cysts, and at last in bending up again vertically they unite to form the outer shell-layer. Each lamella is of a very singular structure. It is finely papillate on the inner or upper side, and in consequence grooved on the outer side when the lamellæ touch each other, but nearly smooth on the outer side when they are disunited. To this character may be traced the punctation of the shell when the outermost shell-layer is removed, as this layer leaves on the underlying shell-lamella the impression of the papillæ of its inner side, and these appear as punctation. The real punctation is in connection with the papillæ, not with the grooving; as apparently on the smooth outer or lower faces of the lamellæ the punctation consists only of very fine pores which are not situated in grooves.

In the Records of the Survey (*l. c.*), in describing the microscopical structure of the shell, I stated that all the lamellæ show a fine striation, vertical to their plane, and that this striation is very likely owing to each being formed of vertical prisms. Fresh preparations, admitting of the application of a more strongly magnifying power, have now shown me that this striation is not caused by prisms, but by a very densely set perforation of the shell. Each papilla on the upper or inner side of the lamellæ forms the entrance to a very fine narrow canal, which mostly penetrates one or more of the lamellæ and then splits up into two or three branches, terminating either at one of the cysts or below the outermost layer of the shell. I was so fortunate as to secure the aid of one of the most celebrated microscopists now living on the Continent, Dr. Conrad Schwager of Munich, for the execution of Plate LXXXII, on which are represented microscopical sections of the substance of the shell of several molluscs, molluscoids and corals, and with them a longitudinal section through the shell of ***Richthofenia.*** For the correctness of the drawings the name of Dr. C. Schwager is an absolute guarantee, and from this drawing it most clearly appears that these canals split up into several branches. This plate may serve at the same time as a standard to judge the correctness of the drawings on Plate LXXXIIA, executed by Mr. A. Swoboda.

On this latter plate there is a figure representing a section through the shell of *Richthofenia* parallel to the surface. The papillation and the canals which pierce the lamellæ in connection with it can be distinctly seen, and owing to the unevenness of the shell, the cysts also are partly uncovered. Another feature, however, the meaning of which I was quite unabl eto make out, is the radially-striated organs which appear in this section. They certainly do not belong to the root-like tubes with which the larger valve is provided; they might perhaps be attributed to the polygonal straight shell-tubes, which have been described above. Another figure on the same plate represents a vertical section through that thickened part of the shell which fits into the emarginations of the smaller valve at both ends of the hinge-line. What is chiefly remarkable in this section is the great frequency of thin, straight tubes ascending nearly vertically.

If we compare all these sections with those of ***Productus, Derbyia, Calceola,*** and ***Radiolites,*** represented on Plate LXXXII for comparison, we find that the greatest similarity exists between ***Productus, Derbyia,*** and ***Richthofenia,*** whilst the shells of *Calceola* and ***Radiolites*** are not at all comparable. This result is perfectly in accordance with the opinion already given by Kayser from a simple inspection of the shell with a lens, that the structure of the shell of ***Richthofenia*** had the greatest similarity to that of *Strophomena or* ***Productus.***

To give measurements of these fossils is barely possible, as their external shape is so extremely variable that two specimens never entirely resemble each other. From the numerous figures of this species it will not, however, be difficult to get an idea of the range of variation in size and shape these fossils are subject to.

The species is gregareous in its occurrence in nature, and the individuals are often so closely packed together, that the root-like appendages of one individual are fastened to the individuals around; but I never found two individuals entirely grown together.

Locality and geological position.—The species is very common at certain localities in the Salt-range; most so in the middle division of the Productus-limestone. In the lower division it is also not rare at some places, but on the whole much rarer than in the middle division. In the upper division it has also been found at many localities, but is everywhere rare, and in the topmost beds of the formation it is entirely absent.

It has been collected by myself at Amb in the lowest fossiliferous beds of the whole formation, just above the lavender-clays (11 specimens).

At Katta I collected a specimen in the lowest beds of the compact limestones which compose the middle division (bed No. 12 of the section in my note-book).

In the middle region of the middle division I collected the species at Virgal in the coral beds (11 specimens), as well as in the crinoid beds (1 specimen), in the Chittawán (19 specimens), at Katta (1 specimen), and Trans-Indus at Káfirkot (2 specimens). Mr. Wynne collected the species in the same beds at Morah (1 specimen), and Trans-Indus at Bilot in the crinoidal cliffs (1 specimen), as well as on the top of those cliffs (2 specimens), and at Omarkheyl (1 specimen).

In the upper region of the middle division the species has been found by Dr. Warth and Mr. Wynne at Musakheyl (5 specimens), and by myself in the section at Khura in the uppermost beds of the division (1 specimen).

In the upper division the species has been collected by myself, west of Khura, at the very base of the division (1 specimen), as well as somewhat higher up (1 specimen). Also, Mr. Wynne found a specimen in this division at Jabi. The geologically youngest specimens were detected by myself in the *Cephalopoda* bed of Jabi (4 specimens), as well as in that of Chidru (1 specimen). Higher up the species does not extend.

Remarks.—There are not many remarks to be made about this species, as everything regarding its systematic position has been stated already in the introduction to the family.

As regards the geographical distribution of the species, it is restricted to the Salt-range, and has not yet been described from any other country The shells which have been figured by Kayser from China under the name of *Richthofenia lawrenciana*, Kon., do not belong to this species, but are distinct from it by a shorter hingeline and an altogether thinner shell-substance.

2. RICHTHOFENIA SINENSIS, Waagen; Pl. LXXXII A, fig. 4.

1883. *Richthofenia lawrenciana* (Kon. sp.), Kayser: Richthofen's China, vol. IV, p. 195, pl. XXIV figs. 4-5 (non Koninck).

I have created this name for the species of Richthofenia that has been described by Kayser from the upper-carboniferous beds of Lo-Ping in China.

This species is characteristically distinguished by a very insignificantly developed hingeline, which is often so short as to be barely perceptible, as for instance in the specimen figured by Kayser, fig. 4 b. A hingeline is, however, present in this case also. Though this character is the most striking one, yet there exist also others by which the species may be recognised.

The thickened parts of the larger valve which fit into emarginations of the smaller valve at both ends of the hingeline in the Indian *Richthofenia lawrenciana* are absent in the Chinese shell. Then there is something like a median sinus observable in the smaller valve; and the larger valve bears more prominent and sharper wrinkles on its surface.

Of the interior characters of the Chinese shell little is known; it can be stated that on one of the specimens at least the general internal arrangement is similar to, but not identical with, that of *Richthofenia lawrenciana.* The shape of the partitions in the large valve is well observable on the smaller of the Chinese specimens. One of the partitions has been exposed by the breaking off of the apex of the larger valve. The tolerably smooth surface exhibited by this fracture was taken by Kayser to be the impression of a foreign body to which the shell had adhered; but an inspection of the specimen immediately convinced me that it was one of the partitions that was here exposed. The surface of these partitions is finely granulated; the form, however, is considerably different from those of *Richthofenia lawrenciana.* The rounded saddle which extends from the vertical septa to the wall of the shell opposite the hingeline occupies nearly the entire breadth of the shell, and the broad hollows on both sides of the saddle in the Indian species are here reduced to mere narrow fissures along the lateral walls of the shell. Not far from the frontal wall of the shell, opposite the hingeline, the partition bears a very characteristic little groove, which appears as a small knob on the lower face of the partition as exposed in the specimen serving for description. In the vicinity of the hingeline a triangular space is marked off, owing to the bending up of the partitions on the three vertical septa; the triangle is limited on one side by the hingeline, and towards the apex by the area. All this is exactly as in *Richthofenia lawrenciana.* The area, however, owing to the insignificant development of the hingeline, is very narrow, but yet very distinctly limited on both sides by sharp edges. It bears in the middle a broad flatly-arched pseudodeltidium. All these parts are covered up and concealed as in the Indian species by an exuberant growth of the shell, but they can be distinctly seen in fractured places of the Chinese specimens.

The *Richthofenia sinensis* is, moreover, distinct from *Richthofenia lawrenciana* by the very small development of the cystiferous part of the shell-substance in the larger valve.

Locality and geological position.—The species was originally described from China, as has been remarked above; but it seems to occur also in the Salt-range. At least I should be inclined to associate with this species a specimen collected by myself at Nursingpohar in the black beds forming there the lowest part of the middle division of the Productus-limestone.

Remarks.—The specimen from Nursingpohar that I assign to this species is not sufficiently well preserved to allow of a quite exact determination, but the configuration of its partitions, the only character which can be exactly observed, is so absolutely identical with *Richthofenia sinensis*, that I cannot avoid comparing this shell with the Chinese species.

The occurrence of this Chinese form in the Salt-range would be of much geological interest.

Order: LYOPOMATA.

Sub-Order: *GASTEROPEGMATA* sive *CRANIACEA.*

Family: *CRANIADÆ.*

It is with some hesitation that I undertake the description of the *Lyopomata*, as the materials on which this description must be founded, though partly very numerous, are yet somewhat incomplete owing to the great difficulties that have to be surmounted in exposing the inside of these shells, which are mostly of an extreme thinness and fragility.

Though the Craniadæ make an exception to this general rule, yet in this family also I cannot present a full description of the several forms; it remains even doubtful whether the shells which I place in this family do really belong to it. This uncertainty is caused by the circumstance that of the *Crania*-like shells occurring in the Salt-range, only the lower and adhering valve is known to me, while the upper or free one has not yet been found. If, therefore, the description of the *Lyopomata* should be found rather unsatisfactory, the reason is to be sought for in the incompleteness of the materials, whereby the control of observation by the preparation of several specimens is nearly impossible. The forms of this order occuring in the Salt-range are, however, of too much interest to be overlooked; so I give what I can, looking forward to fuller information from new studies undertaken under more favourable circumstances.

The *Craniadæ* form a very compact little group of shells, which even may attain the rank of a sub-order; the generic distinctions are, however, rather difficult, and founded on not very prominent characters. Zittel, in his Handbook of Palæontology, considers the family to contain only the single genus *Crania*, which is divided again into a number of sub-genera. Dall, on the contrary, distinguishes the following genera within the family :—

CRANIA, Retzius, 1781 (Schrift. Berlin. Ges. naturf. Freund., II, p. 72).
CRANISCUS, Dall, 1871 (Bull. Mus. Comp. Zool. III, pt. I, p. 26).
ANCISTROCRANIA, Dall, 1877 (Bull. Unit. States Nat. Mus. No. 8, p. 13).
PSEUDOCRANIA, M'Coy, 1851 (Ann. & Mag., Nat. Hist., vol. VIII, p. 388).
CHONIOPORA, Schauroth 1854 (Zeitschr. Deutsch. Geol. Ges., vol. VI, p. 546).

If we now compare with these genera the shells figured on Plate LXXXIV of this work and supposed to belong to the *Craniadæ,* we find that they deviate totally, and indeed appear so very dissimilar to all the shells comprised within the family, that it might even be questioned whether they should be placed at all with *Craniadæ.*

The only characters which induce me to place the specimens in that family are the calcareous composition of the shell, the peculiarity that one of the valves is fixed by its entire surface to foreign bodies, and finally the absence of any trace of hingeteeth.

Though these characters combined make it highly probable that these shells belong to the *Craniadæ,* yet the decisive characters based upon the arrangement of the muscular impressions cannot be observed in the Indian fossils, and thus their systematic position must remain to a certain extent doubtful.

For these Indian forms, of which the lower valve only is known up to the present, I introduce the generic name of *Cardinocrania.*

The genus has only been observed in the Salt-range, and is not very common there.

Genus: CARDINOCRANIA, Waagen, n. gen.

This genus is founded on lower valves only, the upper valves not being known to me.

The lower valves are of small dimensions, fixed by the entire surface to foreign bodies. Their general outline is more or less transversely oval, with a short straight hingeline on one side, and a more or less strong indentation on the opposite or frontal side.

The existence of such a hingeline is very peculiar, and ought to be indicated in the name.

The valve all round spreads out with a thin and flattened margin, which also is fixed to the supporting body.

In the interior of the valve the most conspicuous part is a thin, triangular, shelly plate, fixed by its broad base to the cardinal region of the valve, and extending with its narrow and indented extremity to not far from the front. It is supported in the middle by a short low septum. This plate probably served for the support of the different muscles, but of the impressions nothing can be distinguished in any of the specimens at my disposal. This is all I can say of the structure of the genus.

There cannot be the slightest doubt that the shells bearing these characters are generically different from all the other groups of the *Craniadæ.* Though the smooth, not granulated, shell-margin to a certain extent recalls *Pseudocrania,* yet the very distinct hingeline, strongly marked off by emarginations from the remainder of the valve, is a character by which the Indian shells deviate not only from all the genera of the *Craniadæ,* but from all the *Lyopomata* together.

In the Salt-range the genus is only represented by a single species, which has, however, a very extensive range. It commences already in the lower division of the Productus-limestone and extends through the whole formation. The species never occurs in great numbers.

The genus has not yet been observed in any part of the world except the Salt-range; and even from there it is very incompletely known, as only lower valves have been found up to the present.

CARDINOCRANIA INDICA, Waagen, n. gen. et sp.; Pl. LXXXIV, figs. 1, 2.

The species is of a rather small size, barely exceeding a breadth of 8 mm., and still smaller in length.

The lower valve, which alone is known, is always of a more or less transversely oval shape, and very little elevated in thickness. It is fixed by its entire under-surface to foreign bodies, and when well preserved shows always more or less largely spread-out margins, which creep along over the body to which the valve is fixed. The outline of the valve is thus not very well defined, and its contour is chiefly determined by the figure assumed by a highly elevated ridge, which on all sides surrounded the animal and on which the other valve must have rested. Within this ridge the excavated part of the valve is situated.

The figure described by this ridge is transversely oval on the whole. The lateral parts are well rounded, and in the middle of the frontal region there exists a more or less deep emargination. Opposite the front line the lateral parts ascend in a gentle curve towards the middle line, then suddenly bend out again and join a tolerably long well-developed straight hingeline under acute angles. The hingeline itself forms a narrow sharp edge, limited on its outer side by a steeply descending smooth plane, and overhangs slightly on its inner side. In the acute angles on both sides, where the lateral shell-walls join the hingeline, there terminate deep furrows, which commence in the middle under the hingeline. From the spot where these furrows unite, a flat triangular space extends, occupied by a thin, somewhat lozenge-shaped, shelly plate, which probably served for the support of the muscles. This plate is fixed for a certain extent to the upper part of the lateral walls of the valve, whilst its median part hangs far down, nearly to the frontal region. Its lateral outline is deeply cut out in a rounded line, and the median part is slightly bi-lobed, the lobes being a little bent up so as to produce a short furrow in the middle. If the plate is broken, one sees that it is supported from the bottom of the valve by a short, rather thick septum. The lateral parts of the valve are much more deeply sunk in than the plate which has just been described.

The expanded margins of the valve seem to be extremely finely granulated, but the space occupied by the animal appears to be quite smooth. On the elevated ridge which surrounds the excavated part of the valve, a slight impression can be observed at certain places, chiefly in the vicinity of the hingeline, evidently caused by the other valve. From this it appears probable that the upper valve partly fitted into the lower one.

Neither muscular nor vascular impressions can be distinguished.

The dimensions of three specimens, Nos. I and II from Morah and No. III from Jabi, are, as far as they can be taken, as follow:—

	I.	II.	III.
Length of the shell	7 mm.	4 mm.	5·5 mm.
Breadth of the shell	8·5 "	7 "	9 "
Length of the hingeline	4 "	3·5 "	4 "
Thickness of the lower valve	1 "	0·5 "	1·5 "

Locality and geological position.—It is very difficult to indicate exactly the geological range of the present species, as the specimens must be well preserved to allow of an exact determination. This arises from the circumstance that the young specimens of *Strophalosia*, adhering to foreign bodies, if not very well preserved, look exactly like the present species when not well preserved, and it is impossible in such cases to say which is which. Thus it is very difficult to say in what special beds the present species occurs and where it is more abundant, as though I am convinced that many of the badly preserved specimens adhering to other shells belong to the present species, yet I cannot be certain of it. Thus, for instance, I cannot say for certain whether the little things found occasionally in the lower Productus-limestone adhering to the shells of *Spirifer*, &c., belong to the present species or not, though it seems probable that they do. The occurrence of the species in the middle Productus-limestone, however, is beyond any doubt, as the well-preserved specimens from Morah, represented on Plate LXXXIV, fig. 1, are from that division. It is equally certain that the species occurs in the upper Productus-limestone, as the excellently preserved specimen represented in fig. 2 of the same plate was found by myself in that division in the *Cephalopoda* bed at Jabi.

Remarks.—There is no need, as far as I am aware, to indicate for the present species any characters distinguishing it from other forms, as the species is so isolated that it cannot easily be mistaken for any other. Even generically it is but very little related to other groups. Among the *Craniadæ*, *Pseudocrania* might perhaps in a general way be compared. If in *Pseudocrania* we take as a whole all the space on which the muscular impressions are distributed, it somewhat resembles in shape the triangular muscular plate in our species; but there is no hingeline in *Pseudocrania*, and thus the similarity ceases. As regards the hingeline, slight traces of such have been figured in jurassic species of *Craniscus*, but that part is not at all so strikingly developed in these forms as in our *Cardinocrania*.

This hingeline puzzled me a good deal, and at last I came to compare it with the same part of two other fossils from the Salt-range, *Lyttonia* and *Richthofenia*. The similarity of the hingeline and surrounding parts with *Lyttonia* is chiefly striking, and perhaps I should better have placed the *Cardinocraniæ* altogether in the *Thecideidæ*, sub-family *Lyttoniinæ*, instead of in the *Crainadæ*, but the complete absence of any trace of hingeteeth in *Cardinocrania*, which are present, though rudimentary, in *Lyttonia*, prevented me from doing so. Otherwise there is little similarity between *Cardinocrania* and *Lyttonia*; so the former may as well be placed among the *Craniadæ* until fuller information about it will be available.

A similar configuration of the hingeline is also observable in *Richthofenia*, and for a time I was even doubtful whether *Cardinocrania* was not the juvenile state of *Richthofenia*; but after a lengthened consideration I came to the conclusion that this was very improbable, at least traces of the vertical septa and of the pseudodeltidium ought to be observable in the quite young state. That *Richthofenia* shows otherwise a certain affinity to the *Craniadæ* has been stated above. On the whole, the obscure relations that may perhaps exist between these three genera are very remarkable, and some questions may yet have to be solved in this direction. There may really exist a transition between *Cardinocrania* and *Richthofenia* on the one hand, and between the former and the *Thecideidæ* on the other; so that the limit between the *Arthropomata* and the *Lyopomata* would no longer have to be considered so strictly drawn as has been done up to the present.

SUB-ORDER: DAIKAULIA sive DISCINACEA.

Family: *DISCINIDÆ.*

This small family is, like the *Lingulidæ*, of very ancient date. The forms belonging to it all possess a very thin, horny, calcareous shell, and are characterised by the position of the peduncle; it is not marginal, but approaches more or less the centre of the lower or ventral valve, which is either slightly open from the margin to near the centre, or bears a slit-like foramen extending from the centre to near the margin, or finally a small foramen pierces the shell somewhere within this distance.

This position of the peduncle seems to me the essential point in assigning a genus to this family or not, the punctation of the shell, which is also present in most genera, being only of minor importance. Thus I am not quite inclined to follow Zittel's Handbook, which puts *Trematis* and *Schizocrania* in the *Obolidæ*, retaining only *Discina* and *Paterula* in the present family. Dall, on the contrary, seems rather to share my view in the matter; thus he places the following genera in the family:—

1. DISCINA: Lamk., 1819 (Hist. an. s. vert., vol. VI, p. 236). Silurian to recent.
2. DISCINISCA: Dall, 1871 (Bull. Mus. Comp. Zool. Cambr., vol. III, p. 37). Silurian to recent.
3. TREMATIS: Sharpe, 1847 (Quart. Journ. Geol. Soc. Lond., vol. IV, p. 66). Silurian.
4. ORBICULOIDEA: Orbigny (1847 ?), 1849 (Comptes Rendus XXV, p. 269, Prodr. Pal. Strat. Sil., p. 21). Silurian to cretaceous.
5. SCHIZOCRANIA: Hall and Whitfield, 1875 (Palæont. of Ohio, vol. II, p. 71, pl. 1, figs. 12-15). Lower-silurian.
6. ACROTHELE: Linnarsson, 1876 (Bihang till k. Svenska Vetensk. Akad. Handling., vol. III, No. 12, p. 20).

The genus *Paterula,* Barrande, which has also been placed by Zittel in the family *Discinidæ* is but very imperfectly known; but from the general configuration of its little valves, I should rather be inclined to place it in the family *Lingulidæ* than in the *Discinidæ.* Mr. Davidson, however, whose admirable last part of the British Brachiopoda has just reached me, places the genus definitively in the latter family. With regard to *Schizocrania,* he expresses some doubt whether it is not a *Discinocaris.*

In the Salt-range the family *Discinidæ* is but doubtfully represented by a single (or perhaps two) species of rather uncertain general affinities. I place the fossil in this family on account of a rather broad and deep incision on the margin of the ventral valve for the passage of the peduncle. The external appearance of the shell recalls to a certain extent that of *Trematis,* which also seems sometimes to bear such a slit-like incision on its lower valve, but in the Indian shell the apex is more eccentric and the sculpture entirely different from *Trematis.*

From this it appears rather probable that we have to deal here with a new genus, for which I introduce the name of *Discinolepis.* In introducing this new name, I feel very keenly how desirable it would have been to ascertain also the internal characters of the shells; but on the one hand specimens of this form are very scarce, and on the other it is extremely difficult to clean the inside from the adhering rock; and as it was very uncertain whether I should be successful in making a preparation, I did not venture to destroy one of the few specimens.

If the genus I thus introduce is not founded on very firm ground, the new name at least avoids the union of this form with another group of shells, with which it does not well agree, and the name of which would perhaps be suggestive of geological conclusions.

Genus: DISCINOLEPIS, Waagen, n. gen.

The shell is of very small size with two unequal valves, which are very flat, leaving scarcely any room for the animal between them.

The lower or ventral valve is hardly at all vaulted in any direction, and appears flatly spread out like a small fish scale. Only the apex is a little elevated. It is removed from the margin towards the median part of the valve. The margin of the valve nearest the apex is broadly cut out by a deep incision reaching to the top of the apex.

The upper or dorsal valve is in shape similar to the other one, with a slightly elevated eccentric apex, but without an incision.

The surface in both valves is either smooth or covered with a fine granulation.

From this description it appears that the present genus is different from all the other genera of the *Discinidæ* hitherto described. From *Discina, Discinisca,* and *Orbiculoidea,* it differs in having an incision and not a slit-like foramen in its lower valve for the passage of a peduncle. In *Trematis* a similar incision or emargination seems sometimes to occur, but the sculpture of the valves is quite different from that occurring in *Discinolepis*. *Schizocrania* has an incision, but it is much larger than in the Indian form.

The genus is represented perhaps by two species in the Salt-range, but only one of them is sufficiently well preserved to be described.

DISCINOLEPIS GRANULATA, Waagen, n. gen. et sp.; Pl. LXXXVI, figs. 5, 6, 7.

The general outline of this species is more or less transversely oval to nearly circular. The two valves are of equal size and shape; both very small, not exceeding a diameter of 5 mm.

The upper or dorsal valve is not well accessible to my observation, as no entire specimen of it is preserved in the Salt-range collection. There is only the somewhat elevated and obtusely pointed apical part preserved, while the flatly expanded larger part of the valve is always broken. These fragments show the margin of the valve preserved on one side in the vicinity of the apex. This margin is entire, and nowhere cut out. The apex is but very little removed from the margin, and forms the culminating point of a narrow and but slight elevation, overhanging very little towards the centre of the valve. The surface of the fragments accessible to my observation is shining smooth without granulation.

The lower or ventral valve can be more completely described, as far better specimens are preserved. This valve is nearly quite flat, only a little space in the vicinity of the apex being slightly elevated. The margins are well rounded, and only on one side is there a broad slit or incision reaching to the top of the apex, but without the slightest indication of an area. The apex is not situated far inside the valve, but approaches the margin rather nearly on the side on which the incision is situated. It is but slightly elevated, obtusely pointed, and has a rather flatly sloping face towards the margin and a rather steep one towards the centre of the valve. The whole surface of the valve is covered with fine papillæ, between which can be observed faint striæ of growth, all starting from the margin on which the incision is situated.

The dimensions of two ventral valves are as follow :—

	I.	II.
Entire length	4·5 mm.	4·5 mm.
„ breadth	6 „	5 „
Elevation of the apex	0·5 „	0·5 „
Extent of incision	1 „	0·5 „

Locality and geological position.—The species is restricted to the so-called *Obolus* beds of Wynne's description, and seems to be not scarce in these beds, but well-preserved specimens are only rarely met with. The species has been found up to the present at Khewra in the valley above the salt-mines, and at Jutána. From the former locality there is a slab of black micaceous shale, on which dozens of fragmentary specimens of the species are observable. In other beds it seems, however, to occur only sporadically, as the two well-preserved specimens figured on Pl. LXXXVI are solitary.

Remarks.—The little species here described is very isolated in all its characters, and cannot be in particular compared to any shell hitherto made known, as far as I am aware of.

Family: *SIPHONOTRETIDÆ.*

This family, which was proposed by Kutorga in 1848, seems to be in a rather unsettled state as regards its systematic affinities, and thus it happens that nearly every observer gives it a different place in the system.

By Dall, in his index, the family is placed at the head of the *Lyopomata*, next to the *Productidæ;* whilst Zittel in his Handbook distributes in the family *Obolidæ* all the genera classed by Dall as *Siphonotretidæ;* and Davidson, in the last part of his great work, again places the family between the *Craniadæ* and the *Trimerellidæ*. In the *Lyopomata*, where a shelly brachial apparatus is either entirely absent or only rudimentary, the mode of insertion of the peduncle seems to me the best principle of classification, and thus all the *Lyopomata* can very conveniently be brought into several sub-divisions, according to the mode in which the peduncle either protrudes between the valves, or pierces one of the valves, or is even altogether wanting.

The *Craniadæ* have a kind of shelly support for the brachial apparatus, but no peduncle at all. These characters widely separate them from the remainder of the *Lyopomata*, and thus a sub-order for that family as I have above established, can well be justified. Another type is represented by the *Discinidæ*. They possess a peduncle, and any trace of a shelly support for the brachial apparatus is wanting. The peduncle passes through a slit or a foramen in the ventral valve, and is thin and comparatively short. From the *Discinidæ* to the *Siphonotretidæ* there exists, however, a nearly perfectt ransition, as the genus *Mesotreta*, Kut., is different from *Discina* in its external appearance chiefly by the circumstance that the slit-bearing valve is more elevated than the other one, and the foramen just pierces the apex, whilst in *Discina* or *Orbiculoidea* the slit-bearing valve is the flatter one, and the slit-like foramen is shifted towards the margin. From *Mesotreta* to *Acrotreta* and *Siphonotreta*, there are but small steps, and thus it can barely be denied that the *Siphonotretidæ* as a whole are rather nearly related to the *Discinidæ*, and can very well be considered to form together with these a sub-order, for which I have introduced the name "*Discinacea*" or "*Diakaulia*."

The *Obolidæ*, though also rather nearly related to the *Discinidæ*, very probably had a large peduncle protruded between the valves, as in the *Lingulidæ;* and thus I am rather inclined to bring them into closer relation to the latter, and to consider them as a connecting link between the *Discinacea* and a sub-order for which I shall introduce the name of "*Lingulacea*" or "*Mesokaulia*."

The Siphonotretidæ comprise quite a number of genera, of which the following may be recorded :—

MESOTRETA, Kutorga, 1847 : Verh. Kais. Russ. Mineralog. Ges., St. Petersburg, 1847, p. 271, pl. VII, fig. 4.

ACROTRETA, Kutorga, 1847 : *l. c.*, pp. 260-275, pl. VII, fig. 7.

SIPHONOTRETA, De Verneuil, 1845 : Geol. of Russ. and the Ural Mount., vol. II, p. 286.

VOLBARTHIA, Möller, 1873 : Verh. Kais. Russ. Mineralog. Ges., St. Petersburg, 1873, pp. 1-7, l. I, figs. 1-6 ; Neu. Jahrb. f. Min., 1874, p. 449.

Mr. Davidson in the last part of his grand work quotes also *Kutorgina*, Billings, as belonging to the family. I cannot judge of the genus, as I have never seen specimens of it. From the figures I should be rather inclined to place it in the family *Obolidæ*.

A genus that might perhaps be considered as a connecting link between the *Siphonotretidæ* and the *Obolidæ* is *Helmersenia*, Pander, though the existence of a foramen may bring it nearer the former.

In the Salt-range there occur some shells that I should rather be inclined to place in the family *Siphonotretidæ*, though the forms are but very imperfectly known to me, and the materials very scanty. I am, however, quite at a loss as to what genus these shells ought to be placed in. The chief character consists in an area in one of the valves which is slit open in the middle, and seems to be widened on the top into a foramen. Thus these shells hold about a middle position between *Discina*, *Siphonotreta*, and *Lingula*, and it seems to me not advisible to place them in any of the hitherto described genera. To avoid then a misleading position of these shells in a genus to which they very probably do not belong, I rather prefer to make a new genus, though the foundation of it may be rather imperfect ; I shall thus introduce the name of *Schizopholis* for these specimens.

Genus : SCHIZOPHOLIS, Waagen, n. gen.

The shells belonging to this genus are all of very small size. They consist of two valves, of which one is imperforated and rather flat, the other is slightly elevated with a somewhat prominent marginal apex, below which is a small triangular area slit open in the middle by a triangular fissure, which seems to be sometimes a little widened at the top, forming a kind of foramen, placed just at the extremity of the apex.

The shell surface is very finely granular, and it seems as if it had borne spine-like appendages as in *Siphonotreta*, but these are not preserved in any of the specimens at my disposal.

Of the internal characters of the genus nothing is known to me, as there are only three specimens available ; and as the rock, a black micaceous shale, adhered very firmly to the internal side of these shells, it appeared impossible to make a preparation of the inside.

There has been found up to the present only one species of the genus in the Salt-range.

Schizopholis rugosa, Waagen, n. gen. et sp.; Pl. LXXXVI, figs. 2, 3, 4.

1862. *Siphonotreta*, sp. (Waagen) Wynne: Geology of the Salt-range; Mem. Geol. Surv. of India, vol. XIV, p. 87, *et passim*.

This is a very small species of elongately oval or somewhat trapezoidal outline, with one nearly flat and one slightly elevated valve. The latter is provided with a small area, which is apparently cut open in the middle by a broad slit ending at the top in a small foramen. The surface of both valves is rugose with numerous radially arranged wrinkles.

The dorsal valve is nearly quite flat, the apex being only very little elevated. The outline is well rounded, but not quite regularly, the valve being somewhat narrowed in the vicinity of the apex and spread out on the opposite side. The apex is pointed, not quite but very nearly marginal, and but very little prominent. The surface of this valve is much less strongly rugose than that of the other. The radial wrinkles are less prominent and less numerous. They are often slightly swollen where the striæ of growth cross over them, and there is some appearance as if spines had been placed on them. The space between the wrinkles, and apparently the whole surface of the valve, are very finely granular; the character can, however, be detected only with a powerful lens.

The ventral valve is slightly vaulted in the transverse direction and appears very flatly and eccentrically conical longitudinally. Its outline differs somewhat from that of the other valve, as only the part opposite the apex is well rounded. Laterally the outline is rather straight, and in the apical region the median part is prominent, with sloping sides, which join the lateral outline under an obtuse angle. The apex is pointed and prominent, somewhat overhanging and slightly cut out on one side for the passage of a small foramen, the form of which cannot well be seen on account of the deformation of the apex by pressure. Below the apex there is a vertically descending area, smooth, triangular in shape, and marked off on both sides by not very distinct edges. It is apparently cut open in the middle by a broad triangular slit, which seems to extend up to the foramen of the apex, but this cannot be well seen on account of the deformation of the single specimen.

The surface of the valve is very rugose, due to numerous strongly prominent, irregular radial wrinkles crossed by numerous concentric striæ of growth, producing generally a swelling where the two systems of wrinkles meet. On these points there is some appearance as if spiny processes had been broken off. Under a strongly magnifying lens the whole surface of the valve appears finely granular.

Of the interior characters of this species nothing is known to me.

The dimensions of two dorsal valves are as follow:—

	I.	II.
Entire breadth of the shell	5 mm.	4 mm.
„ length „ „	5 „	4 „
Thickness of the shell	0·5 „	0·5 „

An isolated ventral valve shows somewhat different dimensions, which are as follow :—

Entire length	6 mm.
„ breadth	5 „
Breadth of the area	2 „
Height of the area	1 „

Locality and geological position.—There are not more than three specimens of this species known to me, which were all collected in Wynne's so-called "*Obolus* beds." All three were collected by Mr. Wynne and myself in the gorge behind the salt-mines of Khewra.

Remarks.—I regret very much that I cannot give a better description of this interesting little shell. It is very easily distinguishable from all the other forms that occur with it by its rugose surface, which is not exhibited by any other similar shell except by *Siphonotreta*. I have placed this genus and species in the family *Siphonotretidæ* only in a provisional way. That the genus cannot be identified with *Siphonotreta* is evident; but its position in the family may also appear doubtful. On the whole, the genus is rather nearly related to *Discinolepis*, described before, and is distinct from it chiefly by the existence of an area. At all events its position in the sub-order *Discinacea* cannot be wrong.

Sub-Order: MESOKAULIA sive LINGULACEA.

Family: *OBOLIDÆ.*

This family was long ago established by King, but it has not been adopted except by Dall, Zittel, and Davidson. The range given to it by the different authors differs greatly, and it is rather difficult to point out the genera which might really belong to it.

On the whole, the characters of the family are rather simple, and not very difficult to recognise. They consist in a horny calcareous shell with somewhat unequal valves, between which in the apical region the peduncle protruded. The margins of both valves are generally thickened in this region, and the ventral valve bears a furrow in the middle below the apex. Each valve exhibits generally large muscular impressions in the vicinity of its lateral margins.

Zittel in his Handbook has framed the family characters in a very similar manner, nevertheless he has placed all the *Siphonotretidæ* in the family *Obolidæ*, though they have a perforated ventral valve. Dall, however, and Davidson have very properly separated the *Obolidæ* from the *Siphonotretidæ*.

According to the authors quoted, the family would contain the following genera :—

1. Obolus, Eichwald, 1829 : Zoolog. Special. I, p. 274. Silurian.
2. Obolella, Billings, 1861 : New Spec. of Silur. Foss. I, p. 6-7, fig. 7. Cambrian, silurian.

3. MONOBOLINA, Salter, 1865: Mem. Geol. Surv. Great Brit., vol. III, p. 334. Cambrian, silurian.
4. SCHMIDTIA, Volborth, 1869: Verhaudl. Kais. russ. Mineralog. Ges. St. Petersburg, 2 ser., vol. IV, p. 208. Silurian, devonian.
5. KEYSERLINGIA, Pander, 1861: Bull. Imp. Acad. Sci., St. Petersburg, vol. III, p. 46, pl. II, fig. 1. Silurian.
6. ACRITIS, Volborth, 1869: Verh. Kais. russ. Mineralog. Ges., St. Petersburg, 2 ser., vol. IV, p. 212. Silurian.
7. LEPTOBOLUS, Hall, 1872: 24th Regent's Rep. New York State Mus. Nat. Hist., p. 226 (Perhaps identical with *Acritis*.)
8. SPONDYLOBOLUS, M'Coy, 1852: Ann. and Mag. Nat. Hist., vol. VIII, p. 407. Cambrian, silurian.

All these numerous genera are of almost exclusively silurian distribution, and it must appear somewhat strange that this family should be rather largely represented in the Salt-range in beds that cannot be very far distant in age from the true Productus-limestone, which is according to the most probable deductions that can now be drawn, in its upper part at least not older than the magnesian-limestone or the permian of Europe, and in its lower division does not exceed in age the uppermost coal-measures of North America. According to what has been said on pages 6-8 of this volume, the age of these "*Obolus*" bearing beds can then barely be more than that of the lower-carboniferous. A circumstance which makes these deductions probable also from a palæontological point of view is, that although forms agreeing in family characters with silurian shells are numerous, yet these deviate so far from the hitherto described silurian species, that not only they cannot be specifically identified with the latter, but all are even generically most decidedly distinct. And this is not only true within the family *Obolidæ*, but also in all the other families of the *Lyopomata*. Thus a considerable lapse of time must have occurred before *all* the forms could have been changed into differing generic groups; and the view that the beds in which these forms are found belong to the carboniferous period gains much in probability.

There are no obvious reasons why the *Obolidæ* and similar families should have become extinct after the silurian period, and nobody can deny the possibility of their having lived on somewhere on the globe after those times. So much the more must it be interesting to see them re-appear in the Salt-range in beds that are in more or less close connection with permian and upper-carboniferous strata, from which circumstance they may with much probability be taken as lower-carboniferous.

The *Obolidæ* of the Salt-range were detected about contemporaneously by Dr. H. Warth and Mr. Wynne, who both sent specimens for determination to Dr. Stoliczka at Calcutta. None of these specimens exhibited the inner surface, but as the outward appearance was very similar to that of *Obolus*, it was only natural that Dr. Stoliczka should have determined them to be *Oboli*, and the beds in which they occur to be silurian; an opinion in which I fully concurred at the time with my distinguished friend. On my return after a season's work in the Salt-range, I was no longer so firm in this opinion as before, as I had observed the close connection of the so-called

Obolus-beds with carboniferous strata, but the riddle of *Oboli* occurring apparently in more recent strata than silurian remained unsolved. Only after having received the Salt-range materials in Europe, and after having compared the Indian specimens with Russian shells, was the riddle resolved, as I observed that the *Oboli* were no *Oboli*, the *Siphonotretæ* no *Siphonotretæ*, and so on; so that an entirely new fauna of *Lyopomata* slowly developed itself before me.

This result was, however, obtained only after much labour. The specimens always occur with their shells adhering firmly to a strongly micaceous rather hard slaty shale, and an internal cast is never to be found. At last I fastened the shells by their outerside with Canada balsam to glass slides, and was then able with chisels to clear the inner side from the adhering rock. Owing to the extreme thinness of the shells it may be imagined that the operation was most difficult and tedious, and it may be excused that the results are not so complete as could be desired. The muscular impressions were for the most part obliterated, and my indications in this direction must be rather uncertain. But the forms have been found to contain features of a firmer structure, as septa, etc., so that a generic determination could well be made without an intimate knowledge of the muscular impressions. Better results may be obtained when specimens freshly taken from the rock *in situ* can be operated upon, as then the rock is much less hard, and less firmly adhering.

I thus came at last to learn that the so-called *Oboli* of the Salt-range belonged chiefly to two different forms, one rather nearly related to the genus *Obolus*, but yet easily distinguishable, the other very widely deviating, and probably not belonging even to the family, but rather to the *Trimerellidæ*, in which it might be placed near the *Dinobolus*.

The form which I shall retain in the family *Obolidæ* is characterised by a large septum in the dorsal valve; it will bear the name of *Neobolus*, Waagen.

Genus: NEOBOLUS, Waagen, n. gen.

This genus consists of rather small shells, with a roundish outline, and not quite equal valves, the ventral one being generally protracted into a little beak with a furrow on its underside, while the other has only a somewhat thickened cardinal margin. Both are equally arched, but very slightly. The substance of the valves is very thin, horny, calcareous.

The interior of both valves is tolerably well known to me; only the muscular impressions are somewhat doubtful, as in chipping out the stony matter the innermost coating layer of the shell substance also very often splits off, and then the muscular impressions, which are always rather faint, are more or less obliterated.

In the ventral valve the cardinal margin is not much thickened, and is interrupted in the middle by a rather broad, transversely striated furrow, which served for the insertion of the peduncle. Inside this furrow in the depth of the valve, laterally from the middle line, there are apparently two small muscular impressions, probably of one pair of adductors. The other pair of adductors seems to have left its impressions about in the middle of the valve, just above a short thickened ridge or knob which occurs there; but the two impressions that exist in Obolus are here apparently combined into one. On the lateral parts of the valve there are two pairs of very large impressions, of which one partly covers the other; which, if any, of these are muscular impressions, cannot be decided; they must in such case be the impressions of the divaricators.

In the dorsal valve the cardinal margin is arched and very little thickened, except in the middle, where a strong, thick callosity of a somewhat triangular shape is situated, bearing on top a somewhat uneven platform, which apparently served for the insertion of the muscle of the peduncle (umbonal muscle?). This callosity is prolonged towards the interior of the valve into a strong median septum, which sometimes takes its origin immediately at the callosity, sometimes at a little distance from it, and extends to not far from the front of the valve. Of muscular impressions but very little can be seen in this valve. Along the lateral margins a pair of large elongated impressions extend; they may perhaps be taken as the impressions of the divaricators. In the corner between these and the cardinal margin another pair of impressions seems to occur, but very indistinctly. Of the median pair of adductors nothing can be distinguished. Besides the muscular impressions and the septum, there are in both valves some more or less strongly developed radiating lines, slightly raised, the meaning of which I do not apprehend.

These are the characters of the genus; and it appears obvious that shells bearing these characters cannot belong to the genus *Obolus*. The characters of the genus *Obolus* have been admirably illustrated by Davidson, Quenstedt, Zittel,[1] etc.

We can now compare the Indian shells with *Obolus*. As regards the larger or ventral valve, we find that the cardinal margin is considerably thickened; the furrow for the passage of the peduncle is not very broad, and from the inner side of it a strong median septum projects and reaches down to about the middle of the valve. Of the adductor impressions one pair is situated in the corners between the septum and the cardinal margin, and the other on both sides of the median termination of the septum. All these are characters in which the Russian shells deviate from our *Neobolus*. The latter has a very little thickened cardinal margin and not a trace of a septum, and also the muscular impressions seem to be differently arranged.

In the dorsal valve also, *Obolus* presents a very strongly thickened semi-lunar cardinal margin, which sometimes bears a slight indication of a furrow in the middle. One pair of the adductor impressions is situated immediately below this margin, laterally from the middle line; the other pair is to be found about in the middle of the valve, but rather distant from the middle line, leaving a broad smooth space between them. There is not a trace of a septum in this valve. In *Neobolus* the dorsal valve has a thin cardinal margin, provided in the middle with a thick triangular callosity, from which starts a strong septum reaching to near the front.

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[1] In Zittel's Handbook an error occurs, which might be misleading. On p. 664 of vol. I there is a woodcut of *Obolus*, which is said to represent the interiors of both valves and an exterior view of the smaller one. Now, fig. d, which is stated to be the interior view of the smaller or dorsal valve, is in fact a representation of the interior of the larger or ventral valve, copied from Quenstedt's Petrefactenkunde Deutschland's vol. II, pl. 61, fig. 12. There has evidently been a mistake by the artist, who copied this figure instead the one immediately at the side of it (fig. 13) representing the interior of the smaller or dorsal valve.

The differences thus indicated are quite sufficient to distinguish between the two genera.

Of other genera of the *Obolidæ* only *Schmidtia,* Volborth, might perhaps be compared, as in this genus also there is in the dorsal valve a slightly raised middle line, perhaps comparable to a septum. This genus, however, presents in the ventral valve a large area with a deep furrow on it, which is totally wanting in *Neobolus.*

The genus is entirely restricted to the Salt-range, and occurs there exclusively in those beds which received from Wynne the name of *Obolus* beds. I can distinguish among the materials at my disposal two different species of the genus, which will receive the names of *Neob. warthi* and *Neob. wynnei,* in honour of the two first discoverers of these shells.

1. NEOBOLUS WARTHI, Waagen, n. gen. et sp.; Pl. LXXXIV, figs. 3, 4, 5, 6, 7, 8.

1878. *Obolus,* sp. (Stoliczka) Wynne: Geology of the Salt-range: Mem. Geol. Surv. of India, vol. XIV, pp. 68, 87, *et passim.*

The general outline of this species is rather difficult to determine, as most of the specimens are greatly deformed by pressure. On the whole, however, the outline seems to have been about transversely oval, the ventral valve with a slightly prominent beak, and the dorsal one with a rounded cardinal margin. Both valves are very flat, but the actual form of their curvature is barely possible to determine on account of the deformation the specimens have undergone. The surface of the valves is perfectly smooth.

The ventral valve seems to vary somewhat in outline, which is sometimes well and equally rounded on all sides, only the apex being slightly prominent; sometimes, however, there is a distinct cardinal margin developed, which joins the lateral margins of the valve under obtuse angles, and ascends from both sides towards the apex. In the former variety the greatest breadth of the valve occurs mostly in the middle, in the other variety it is to be found more towards the front. As regards the curvature of this valve, it seems to be generally even flatter than the other, having barely any depth at all.

The dorsal valve shows quite the same variations in outline as the other one; but in this valve the form with a well-marked cardinal margin is more frequent than in the other. In this variety the cardinal margin forms an arched line, which joins the lateral margins under obtuse angles; the lateral margins are rather straight and then curve somewhat abruptly round to the well-arched front margin. In the other variety the cardinal margin is also slightly marked off, but the angles under which it joins the lateral margins are so very obtuse as to be almost imperceptible.

The lateral margins are well rounded, and unite imperceptibly with the frontal one. This valve is generally about twice as deep as the other one, and its curvature seems, as far as can be observed, very regular in every direction. The apex is barely perceptible, not prominent, and chiefly marked only by the arrangement of the striæ of growth.

The surface in both valves is smooth and shining, covered with very numerous faint striæ of growth parallel to the frontal and lateral margins and curved round the apex.

The substance of the valves is very thin and often has the ashy-blue colour of vivianite, a circumstance indicating the presence of phosphorus in their composition.

The interior characters of both valves have been represented in detail in the description of the genus.

In the much-deformed state of these shells it is rather difficult to make exact measurements, yet I shall give some indications at least as to the largest ventral (No. I) and the largest dorsal valve (No. II) known to me. The measurements are as follow :—

	I.	II.
Entire length	10 mm.	9 mm.
„ breadth	11 „	10 „
Thickness	I „	2 „

No specimen has been found with both valves adhering.

Locality and geological position.—This is the most common species of the so-called *Obolus* beds of the Salt-range. It occurs in these beds by hundreds, but the localities where it has been found are not numerous. At Khewra it is very abundant, in the gorge above the salt-mines, not far from the place where the fresh-water springs are situated. A small slab of shale, figured on Plate LXXXIV, contains not less than five complete specimens with fragments of several others. Another locality where the species also occurs, but less numerously, is Jutána. Chel hill has also yielded some fragments which perhaps belong to this species.

Remarks.—The present species is, in its outward appearance, chiefly comparable to *Obolus apollinis*, Eichw. Not to speak, however, of the internal differences, it is easily distinguishable from the Russian species by its smaller size and much thinner shell-substance.

Another shell, which is in fact very nearly related to the present one, is *Neob. wynnei*, Waagen, to be described next, from which the species under description is distinguishable by its smooth outer shell-surface, which is concentrically ribbed in *Neob. wynnei.*

2. NEOBOLUS WYNNEI, Waagen, n. gen. et sp.; Pl. LXXXV, figs. 1, 2.

This is an extremely pretty little shell, but rather rare. Its general outline is very strongly oval transversely. The two valves are not very different, flat, extremely thin, and having a very fine concentric sculpture on the outer surface.

The ventral valve is slightly larger than the dorsal one, nearly quite flat, only slightly elevated in the apical region. The apex is pointed and well prominent, but not bent over. From the apex the cardinal margin, which is very distinctly marked off, slopes towards both sides, and meets the lateral margins under obtuse angles. The greatest breadth of the shell is situated not far from the front, and as the cardinal border is much shorter, the lateral margins must strongly diverge, but otherwise they are nearly straight, not much curved; not far from the front they bend suddenly round and unite with the flatly arched frontal margin. The surface of this valve is covered with numerous well-marked striæ of growth, between which an extremely fine concentric sculpturing may be seen, but only with a strong lens and under favourable conditions. This sculpturing consists of very closely arranged, fine, erect lamellæ extending parallel to the frontal and lateral margins.

The dorsal valve is somewhat smaller than the ventral one. It is slightly arched in the longitudinal as well as in the transverse direction, and is most elevated about the middle. The cardinal margin is distinctly marked off and nearly straight. The apex is depressed, not prominent, and on the whole barely at all developed. The greatest breadth of the valve is placed far down towards the front, and thus the lateral margins are rather strongly diverging. They unite with the cardinal border under an obtuse angle and are not much curved; after a rather sudden bend they join the frontal margin, which is very flatly arched. The sculpturing of this valve is very similar to that of the other one, only that the striæ of growth are much less strongly marked. Of the interior characters of this species little is known. In the dorsal valve a callosity below the apex and traces of a median septum can apparently be observed shining through the very thin semi-transparent shell, but of the interior of the ventral valve nothing at all is known to me.

The dimensions of two specimens, No. I, a ventral valve from Jutána, and No. II, a dorsal valve from Khewra, are as follow :—

	I..	II.
Entire length	6·5 mm.	6 mm.
„ breadth	9 „	10 „
Length of the cardinal margin	7·5 „	7 „
Entire thickness	1 „	1·5 „

Locality and geological position.—This species is much rarer than the preceding one; this may, however, to a great extent be due to the state of preservation. The very fine sculpturing which distinguishes this species from the other is easily destroyed, and then it is very difficult to recognise the present form. It has been found at Khewra as well as at Jutána, but at both places only sporadic specimens occur, and there are barely any that I could with certainty assign to the present species except the two figured specimens.

Remarks.—It has already been mentioned that the present species is distinguishable from *Neobolus warthi*, W., by its surface sculpturing. That this is in reality absent in the last-mentioned species, is shown by several specimens, in which, even under a very strong magnifying power, the shell-surface appears shining smooth, with occasional very fine striæ of growth, whilst in *Neobolus wynnei* this surface is quite different.

Family: TRIMERELLIDÆ.

This is one of the best described families existing, and the admirable paper by Davidson and King on these fossils will always be considered a standard work.

It seems unnecessary to repeat here the very complicated family characters, the most striking of which is the existence of a platform in both valves, mostly vaulted and hollowed below, on which the muscular impressions are in part situated.

The genera belonging to the family are not very numerous; and there is considerable agreement between different authors as to the genera which ought to be considered as belonging to the family.

Davidson in the last part of his British Fossil Brachiopoda quotes the following genera:—

1. TRIMERELLA, Billings, 1862: Geol. Surv. of Canada, Palæontology, p. 166, vol. I, fig. 151, a. b.
2. MONOMERELLA, Billings, 1871: Canadian Naturalist, new ser., vol. VI, p. 220.
3. RHYNOBOLUS, Hall, 1871: 23rd Regent's Rep. New York State Mus. Nat. Hist., p. 247, pl. 13, fig. 10. This genus has by most authors been considered identical with *Trimerella*; and also Davidson and King in their paper on the family place the type-species *Rhyn. galtensis*, though with a query, in the genus *Trimerella*. Recently Mr. Davidson seems to have given up this view, in which I perfectly concur with him. *Rhynobolus* seems to me a well distinguishable genus, holding about the middle between *Trimerella* and *Monomerella*, with some characters reminding also of *Dinobolus*.
4. DINOBOLUS, Hall, 1871: 23rd Regent's Rep. New York State Mus. Nat. Hist., p. 247.

All these genera are of an exclusively silurian distribution.

To these has to be added yet one more genus from the Salt-range, for which I shall introduce the name of *Davidsonella*. This genus appears to be somewhat related to *Dinobolus*, yet deviating from it very much. That it belongs to the family, there can be, it seems to me, but very little doubt, though the shell-substance is very thin. The platform in the middle of both valves is so distinct, and in the ventral valve at least so similar to that of *Dinobolus*, that the family cannot be mistaken.

There arises, however, the same difficulty with regard to this genus that has been discussed already with regard to *Neobolus*. The beds in which the *Davidsonellæ* occur in the Salt-range can barely be older than lower-carboniferous, and we have again a most remarkable re-apparition of the family. The long interval of time from the silurian up to the lower-carboniferous would find an adequate expression in the far deviating generic characters of the Indian shells.

Genus: DAVIDSONELLA, Waagen, n. gen.

I create this name in honour of Mr. Davidson, the greatest living authority on Brachiopoda, in order to express once more the great admiration I feel for his unrivalled works. Though his name has been already once connected with a genus of Brachiopod, yet it is appropriate that it should also be perpetuated within the family of *Trimerellidæ* as being one of the most interesting groups of Brachiopoda.

This genus, in comparison with the other genera contained in the family, is composed of shells of a very small size, and the substance of these shells is extremely thin and fragile, in which respect also it differs from other genera of the *Trimer-*

The general outline of these fossils is more or less linguloid, longer than wide, or to a certain extent transversely trapezoidal. Both valves are slightly vaulted, but the ventral one generally more so than the dorsal. At the same time the ventral valve is also larger, and possesses a prominent apex, which is provided on its lower surface with a deep furrow for the insertion of the peduncle.

Of the internal characters of the genus the general features are well known to me, but the details are yet far from being completely ascertained.

In the ventral valve the cardinal margin is somewhat thickened, but not sufficiently so to distinguish an area or a pseudodeitidium. The furrow in the middle is very deep. Below there extends a not very large triangular platform, hollowed out underneath, and supported in the middle by a low partition; this does not, however, extend beyond the platform, so that no septum is visible. This platform is shut in on both sides by low but distinct rounded ridges. These ridges originate below the cardinal margin on both sides of the peduncular furrow, and diverge thence under an acute angle. They descend in a nearly straight line, as far as the platform extends, and then proceeding further in the direction of the frontal margin bend slowly round towards the middle line of the valve. The platform itself is not quite intactly preserved, as its frontal edge is broken, and thus the exact shape of this organ cannot be ascertained. In the middle of it, from near the peduncular furrow to the lower margin, a narrow flat space extends, hemmed in on both sides by narrow furrows. This space probably served, in part at least, for the insertion of muscles. The lateral parts of the platform are concave, instead of being vaulted as in *Trimerella;* yet they are not fastened to the body of the valve, an excavated space remains beneath them.

Of muscular impressions nothing can be observed. Two large deepened spaces along the lateral margins of the valve certainly cannot be taken as such. They have been drawn somewhat too distinctly by the draftsman, the general outline especially being too sharply marked. It seems to me that these deepened places are rather to be taken as the room outside the crescent, so that the somewhat raised inner margin of these impressions would represent a part of the crescent itself. From beneath the platform some fine, diverging, radiating raised lines proceed, the meaning of which is unknown to me. The space outside the semi-circular ridges described above is very finely striated radially.

I am sorry that I am not in a position to describe the interior characters of this valve more accurately or to give a more exact figure of them, but in chipping off the stony matter from the inside minute particles of the valve are always removed at the same time, and thus the inner surface of the valve is at least so far deteriorated that while the general features can be well recognised the details are uncertain and unsatisfactory. This it is impossible to avoid; so that to arrive at any determination regarding these fossils, one must only make the most of the means available.

The internal characters of the dorsal valve are yet more strange than those of the other one. The cardinal margin is but little thickened and slightly curved. In the middle it bears a thickened shelly process very much resembling the prominent tooth in *Trimerella lindströmi.* This prominence is directed somewhat upward and inward, and must have extended partly into the apical cavity of the other valve. From beneath this process a short thickened platform takes its origin; it is not even on top, but to all appearance spirally enrolled. It is concave in the middle and bears on both sides elevated crests with sloping lateral faces. The frontal margin of it is curved inwards, but the whole platform seems to be excavated below, not solid. From its lateral faces there start strongly diverging elevated ridges which divide into two a very short way from their origin. A median septum, which is low at the beginning and highest at its termination not far from the frontal margin, proceeds from under the platform. From both ends of the cardinal margin elevated ridges take their origin; starting at right angles from that margin, they bend again out towards the lateral margins of the valve. Outside of these ridges deepened spaces are to be observed, which probably correspond to the similarly placed deepened spaces of the other valve.

In this valve also muscular impressions are not observable, unless the median impressions on the tooth-like process are to be taken as the scars of the cardinal muscles.

Such are the characters observed in the two valves. If we make allowance for any error due to the bad preservation of the shells, there would still remain the undoubted facts that there is a platform in both valves, and a cardinal tooth and a median septum in the dorsal one, and that the shape of these organs in both valves is quite certain.

But if these points can be taken as well ascertained, the systematic position of the genus can no longer be doubtful. The platform of the ventral valve very much resembles in shape the corresponding part of *Dinobolus*, and the median tooth-like process in the dorsal valve may be exactly compared to the same organ of *Trimerella lindströmi.* If these parts are exactly similar, the remaining organs may at least be typically compared with similar parts in the *Trimerellidæ*; thus there remains for me not the slightest doubt that the genus must be placed in that family.

From the other genera of the family the present one is, however, rather divergent. Already the very thin shell-substance is a character which does not generally occur in the *Trimerellidæ*, except perhaps in *Dinobolus*. The interior characters of

Genus: DAVIDSONELLA, Waagen, n. gen.

I create this name in honour of Mr. Davidson, the greatest living authority on Brachiopoda, in order to express once more the great admiration I feel for his unrivalled works. Though his name has been already once connected with a genus of Brachiopod, yet it is appropriate that it should also be perpetuated within the family of *Trimerellidæ* as being one of the most interesting groups of Brachiopoda.

This genus, in comparison with the other genera contained in the family, is composed of shells of a very small size, and the substance of these shells is extremely thin and fragile, in which respect also it differs from other genera of the *Trimerellidæ*.

The general outline of these fossils is more or less linguloid, longer than wide, or to a certain extent transversely trapezoidal. Both valves are slightly vaulted, but the ventral one generally more so than the dorsal. At the same time the ventral valve is also larger, and possesses a prominent apex, which is provided on its lower surface with a deep furrow for the insertion of the peduncle.

Of the internal characters of the genus the general features are well known to me, but the details are yet far from being completely ascertained.

In the ventral valve the cardinal margin is somewhat thickened, but not sufficiently so to distinguish an area or a pseudodeltidium. The furrow in the middle is very deep. Below there extends a not very large triangular platform, hollowed out underneath, and supported in the middle by a low partition; this does not, however, extend beyond the platform, so that no septum is visible. This platform is shut in on both sides by low but distinct rounded ridges. These ridges originate below the cardinal margin on both sides of the peduncular furrow, and diverge thence under an acute angle. They descend in a nearly straight line, as far as the platform extends, and then proceeding further in the direction of the frontal margin bend slowly round towards the middle line of the valve. The platform itself is not quite intactly preserved, as its frontal edge is broken, and thus the exact shape of this organ cannot be ascertained. In the middle of it, from near the peduncular furrow to the lower margin, a narrow flat space extends, hemmed in on both sides by narrow furrows. This space probably served, in part at least, for the insertion of muscles. The lateral parts of the platform are concave, instead of being vaulted as in *Trimerella*; yet they are not fastened to the body of the valve, an excavated space remains beneath them.

Of muscular impressions nothing can be observed. Two large deepened spaces along the lateral margins of the valve certainly cannot be taken as such. They have been drawn somewhat too distinctly by the draftsman, the general outline especially being too sharply marked. It seems to me that these deepened places are rather to be taken as the room outside the crescent, so that the somewhat raised inner margin of these impressions would represent a part of the crescent itself. From beneath the platform some fine, diverging, radiating raised lines proceed, the meaning of which is unknown to me. The space outside the semi-circular ridges described above is very finely striated radially.

I am sorry that I am not in a position to describe the interior characters of this valve more accurately or to give a more exact figure of them, but in chipping off the stony matter from the inside minute particles of the valve are always removed at the same time, and thus the inner surface of the valve is at least so far deteriorated that while the general features can be well recognised the details are uncertain and unsatisfactory. This it is impossible to avoid; so that to arrive at any determination regarding these fossils, one must only make the most of the means available.

The internal characters of the dorsal valve are yet more strange than those of the other one. The cardinal margin is but little thickened and slightly curved. In the middle it bears a thickened shelly process very much resembling the prominent tooth in *Trimerella lindströmi.* This prominence is directed somewhat upward and inward, and must have extended partly into the apical cavity of the other valve. From beneath this process a short thickened platform takes its origin; it is not even on top, but to all appearance spirally enrolled. It is concave in the middle and bears on both sides elevated crests with sloping lateral faces. The frontal margin of it is curved inwards, but the whole platform seems to be excavated below, not solid. From its lateral faces there start strongly diverging elevated ridges which divide into two a very short way from their origin. A median septum, which is low at the beginning and highest at its termination not far from the frontal margin, proceeds from under the platform. From both ends of the cardinal margin elevated ridges take their origin; starting at right angles from that margin, they bend again out towards the lateral margins of the valve. Outside of these ridges deepened spaces are to be observed, which probably correspond to the similarly placed deepened spaces of the other valve.

In this valve also muscular impressions are not observable, unless the median impressions on the tooth-like process are to be taken as the scars of the cardinal muscles.

Such are the characters observed in the two valves. If we make allowance for any error due to the bad preservation of the shells, there would still remain the undoubted facts that there is a platform in both valves, and a cardinal tooth and a median septum in the dorsal one, and that the shape of these organs in both valves is quite certain.

But if these points can be taken as well ascertained, the systematic position of the genus can no longer be doubtful. The platform of the ventral valve very much resembles in shape the corresponding part of *Dinobolus*, and the median tooth-like process in the dorsal valvo may be exactly compared to the same organ of *Trimerella lindströmi.* If these parts are exactly similar, the remaining organs may at least be typically compared with similar parts in the *Trimerellidæ*; thus there remains for me not the slightest doubt that the genus must be placed in that family.

From the other genera of the family the present one is, however, rather divergent. Already the very thin shell-substance is a character which does not generally occur in the *Trimerellidæ*, except perhaps in *Dinobolus.* The interior characters of the ventral valve can also be best compared with those of *Dinobolus*, though only in a general way and not in detail. The internal features of the dorsal valve are quite peculiar, and, with the exception of the tooth-like process below the cardinal margin, not like anything hitherto described in the *Trimerellidæ*, though on the whole comparable in type to *Trimerella lindströmi*; it thus appears that the genus *Davidsonella* unites characters which are in other cases distributed between *Dinobolus* and *Trimerella*.

Thus the observation recorded above, that the great difference of genera in the "*Obolus* bed" of the Salt-range from those contained in the silurian *Obolus*-bearing strata, indicates the very long time that must have elapsed between the formation of the two deposits, is true also in this case. The difference of *Davidsonella* from the remainder of the genera of the *Trimerellidæ* appears even greater than the differences of these from each other; so that in this case also it is clearly indicated that the Salt-range *Obolus* bed is much more recent than silurian,—a fact that is also borne out by the geological data, as described above (p. 8).

The genus is represented in the Salt-range by two species, which will bear the respective names of *Davidsonella linguloides*, W., and *Davids. squama*, W. Of these the first is not very rare, but the second has been detected up to the present only in one or two specimens.

1. DAVIDSONELLA LINGULOIDES, Waagen, n. gen. et sp.; Pl. LXXXV, figs. 3, 4, 5, 6.

The general outline of this species is mostly linguloid, somewhat longer than wide, the greatest breadth being situated about in the middle of the valves. The two valves are different in size, the ventral one longer with a pointed apex, and the dorsal shorter. Both are about equally vaulted, but never very strongly. The external surface is smooth, with the exception of very fine and very closely set striæ of growth.

The ventral valve is flatly but very regularly vaulted. The margins are rather flatly spread out; thence the valve rises gradually towards the apical region, which is the most elevated part of the valve. This elevation, however, does not exceed 1 millimeter. The outline of the valve is elongately oval, with a distinctly defined cardinal border. The apex is marginal, and the cardinal margin forms a broken line, the most prominent point coinciding with the apex; it unites with the lateral margins under distinctly obtuse angles. The latter present regular flat curves, and unite gradually with the equally well rounded frontal margin. The apex is prominent, and provided on its lower side with a narrow, no very distinct area, which bears in the middle a very deep but not broad furrow for the insertion of the peduncle. Of the internal features the most conspicuous are the curved ribs which start from below the apex, and apparently surround the visceral part of the valve. That the lateral impressions have been incorrectly represented in fig. 6, on pl. LXXXV, has been noticed already in the description of the genus. The representation in the enlarged figure (fig. 3*b*) is more correct.

The dorsal valve is a little less strongly vaulted than the ventral one, but its curve is also very regular. In this valve, however, the apex is not the most elevated part; the greatest elevation is situated at a certain distance from the apex, more near the middle of the valve. The outline of the valve is very regularly rounded with the exception of the cardinal border, which is nearly quite straight, only very slightly arched, and much shorter than the greatest breadth of the valve; it joins the lateral margins under obtuse angles. All the remainder of the outline forms a regularly curved line, there being no demarcation between the lateral and frontal margins. The apex is only marked by the arrangement of the very numerous fine striæ of growth; it is not prominent in any way. It is quite marginal, situated immediately at the cardinal border.

The interior characters of this valve have been discussed in detail in the description of the genus.

The substance of the shell is very thin. With the exception of the numerous striæ of growth the shell seems to be quite smooth, and I cannot detect either punctures or granulations.

As to size, the present species is one of the most conspicuous shells contained in the so-called "*Obolus* beds," though the form shows very moderate dimensions in comparison with other *Trimerellidæ*. The measurements of two specimens from Jutána (No. I, a ventral and No. II, a dorsal valve) are as follow:—

	I.	II.
Entire length of the shell	12 mm.	8·5 mm.
„ breadth of the shell	11 „	9 „
Length of the cardinal border	7 „	6 „
Thickness of the valve	1·25 „	0·75 „

The dimensions are, however, very variable, as these shells are, like all the others occurring in the same beds, subject very much to deformations by pressure.

Locality and geological position.—There are several reasons why it appears very difficult to give numerical indications as to the frequency of this species. As has just been stated, these shells are very much subject to deformations by pressure, and then the general outline cannot be made use of for the determination of specimens in which the interior characters are not visible. These latter are, however, extremely rare, and thus the evidence of the occurrence of the species at different localities is very scanty. It would seem that the species was not rare in the "*Obolus* beds" at Jutána; but, as the determinations were mostly taken only from the outward appearance of the fossils, they cannot be entirely relied upon. So much, however, is certain, that the species is apparently much more rare or even nearly absent at Khewra, above the salt-mines.

Remarks.—There is no species to which the present one could be more particularly compared. That the species belongs to the *Trimerellidæ* is, I think, not very doubtful. The deviation from other forms of the same family is, however, very complete, and indicates again the very long space of time which must have elapsed since the existence of the silurian Trimerellids. Already in *Neobolus* we had only dwarfed forms of the silurian types. This pygmean condition is still more conspicuous in the species of *Davidsonella.* It is not only that the size, which is very conspicuous in the silurian *Trimerellidæ,* has dwindled down to an absolute insignificance but also the solid, or even ponderous, shell of the silurian species has been changed into one of the thinness of paper. The shell thus becomes in outward appearance very similar to *Lingula*—a fact which recalls very much certain cases of atavism; the *Trimerellidæ* beyond doubt took their origin from Lingula, and here we see them return again in their outward appearance to that genus during the last stages of their existence.

2. DAVIDSONELLA SQUAMA, Waagen, n. gen. et sp.; Pl. LXXXVI, fig. 1.

This is a very rare species. Its general outline is somewhat trapezoidal, with a broadly rounded front and a very short indistinctly defined cardinal border. The shell surface is smooth, with a slightly indicated radial folding.

The ventral valve, the only one that is known to me, is nearly quite flat, but very little vaulted, though this flatness may partly be due also to a compression the shell has sustained. The cardinal border is very short and arched, passing gradually into the straight lateral margins. These diverge very strongly and, after a certain distance, bend round to join the rather flatly and broadly curved frontal margin. The apex is but little prominent, pointed, and overhangs slightly the cardinal border.

The surface of the shell is ornamented with many not very sharply developed striæ of growth, crossed by a very faint radial plication, which is chiefly observable at the lateral parts of the valve, being entirely absent in the middle. It consists of broad flattened folds, separated by narrow furrows. With a powerful lens an extremely fine concentric striation can be observed.

Of the interior characters of the shell very little is known to me, as it seemed impossible to expose the inner surface. In the specimen at my disposal there can, however, be seen through the thin shell the two curved ribs which enclose between them the visceral part of the shell, and which are characteristic of the ventral valve of *Davidsonella.*

Other parts, which also are slightly indicated on the outside of the shell by a difference of shading, cannot be made out as to shape, etc., and therefore cannot be identified.

The species is one of the largest occurring in the "*Obolus* beds" of the Salt-range, and the measurements of the single existing specimen, a ventral valve, are as follow :—

Entire length of the valve	13	mm.
„ breadth „ „	14·5	„
Approximate length of the cardinal border	5·5	„
Thickness of the valve	1	„

Locality and geological position.—This species was originally represented by two specimens in the Salt-range collection, both ventral valves only, but unfortunately one of them was broken in trying to expose the inner surface. Both specimens were found by Mr. Wynne in the so-called *Obolus* beds at Jutána.

Remarks.—The present species is very nearly related to the preceding one, but can easily be distinguished by its very short and indistinct cardinal border, and little prominent apex.

That the species belongs to the genus *Davidsonella* cannot be subject to any doubt; though I have not succeeded in cleaning the interior surface of one of the specimens, yet what can be seen shining through the shell-substance is sufficient for the determination of the genus.

Family: *LINGULIDÆ.*

This is the most long-lived family among all the molluscs and molluscoids, as the well-known oldest forms of organised beings belong to this family, and from the very dawn of organic life it extends through all the periods up to recent times.

Though it is to be supposed that in this extremely extended period of existence the family must have been exposed to the most varied outward conditions ever experienced by single forms of organic life, yet the range of variability within the family is smaller than in most other families, and in *Lingula* itself even the generic characters have been retained through all the stretch of time from the silurian to the present period. This is one of the strongest facts that have been brought to the notice of biologists, and one which evolutionists are absolutely at a loss to explain. It very strongly suggests the notion that the real reasons for the variation and evolution of organisms are yet far from being known to us, and that, though the outward conditions may have a great influence, yet they are certainly not the sole reason and cause for the variation of animals, as certainly as the "survival of the fittest" is not the sole reason for the persistency of certain variations. Else we must be prepared to admit that *Lingula* is one of the "fittest" animals that ever was produced, as under all the changes of conditions that it had to endure, it survived thousands and millions of other beings which had apparently a far greater ability to adapt themselves to changed circumstances.

Howsoever this may be, the family comprises a very compact little group of forms, which are rather with difficulty distinguishable from each other. Davidson, in the last part of the British Fossil Brachiopoda, admits the following genera in the family:—

1. Lingula, Bruguière, 1792: Encycl. Méthod. I, pl. 250. Silurian to recent.
2. Lingulella, Salter, 1866: Mem. Geol. Surv. Great Brit., vol. III, p. 333. Cambrian.
3. Lingulepis, Hall, 1863: 16th Rep. Regent's State Cab. Nat. Hist. New York, p. 129, pl. VI, figs. 15-16. Cambrian.
4. Glottidia, Dall, 1870: Amer. Journ. of Conchol., vol. VI, p. 157, pl. VIII, figs. 1-6. Recent.
5. Glossina, Phillips, 1848: Mem. Geol. Surv. Great Brit., vol. II, p. 370. Cambrian, silurian.
6. Dignomia, Hall, 1871: 23rd Rep. Regent's State Cab. Nat. Hist. New York, p. 245, pl. XIII, fig. 3. Silurian.
7. Lingulops, Hall, 1871: 23rd Rep. Regent's State Cab. Nat. Hist. New York, p. 245, pl. XIII, figs. 1-2. Silurian.

One sees from this list that by far the greater part of the genera lived during cambrian and silurian times, whilst in the mesozoic and cainozoic formations only the genus *Lingula* existed, and to that genus only the genus *Glottidia* is added in the present period. From this it appears that the variability of the shells belonging to the genus was by far greater in the most remote periods than later.

I regret to say that I am not in a position to add much to the knowledge of this family from observations made on the materials from the Salt-range. There are amongst them some shells which possibly might belong to the genus *Lingula*, but they are extremely rare, and this scarcity prevented me from studying the inside of these shells, so that their determination as *Lingulæ* must be accepted with great caution. But as there is as little to suggest that they might belong to any other genus, I place them provisionally with Lingula.

There are two different forms which I associate with *Lingula*, but each of them might belong even to a different genus, as one possesses a kind of cardinal border, while the other has none; but, as I know nothing of the interior, they may as well both stand in the genus *Lingula.*

Genus: LINGULA, Bruguière.

The outward appearance of this genus is very characteristic. The shells are nearly always smooth, elongately oval, with not quite equal valves, the ventral one somewhat larger, with a small area, and the dorsal one smaller, but also provided with a kind of very small area, for the insertion of the peduncle. Both valves are rather flat, but very little vaulted.

These outer characters are very characteristically exhibited by two shells occurring in the "*Obolus* beds" of the Salt-range; and chiefly their very elongated oval shape causes me to consider them as *Lingulæ.*

Of the interior characters of these shells nothing is known to me; so the determination must remain doubtful.

Though only two specimens are available, yet they must be attributed to two different species, as one has an entirely smooth shell, and the other slight indications of a radial folding. Both are very small, and in this respect they both recall rather the carboniferous and permian species than the large Lingulæ of more ancient formations.

1. Lingula kiurensis, Waagen, n. sp.; Pl. LXXXVI, fig. 8.

The general outline of this species is strongly elongately oval, with a rather distinctly defined cardinal border, which is considerably shorter than the greatest breadth of the shell.

The ventral valve, the only one known to me, is very flatly but very equally vaulted. The most elevated part is, however, not at the apex, but a little removed from it, somewhat more towards the middle of the valve. The apex is entirely marginal, prominent, pointed, and overhanging the cardinal border. The cardinal margin forms sloping straight lines on both sides of the apex, which join the lateral margins under not very sharply defined obtuse angles. The lateral margins are rather strongly diverging, and but very little curved, nearly straight. After a certain distance they bend slowly round and join the semi-circular frontal margin.

The surface of the shell is quite smooth, only provided with tolerably numerous obtuse striæ of growth.

Of the interior characters of the dorsal valve as little is known to me as of its shape and characters.

The dimensions of the single existing specimen are as follow:—

Entire length of the shell	9·5 mm.
„ breadth „	7 „
Length of the cardinal border	4 „
Thickness of the shell	1·5 „

Locality and geological position.—The only existing specimen of this species was collected by myself at Khewra above the salt-mines, not far from the fresh-water springs, in the so-called *Obolus* bed.

Remarks.—In size the present species appears to be rather nearly related to *Lingula mytiloides*, Sow., from the carboniferous-limestone, or *Lingula credneri*, Gein., from the permian formation. The former especially has in its general outline a certain similarity, in as much as the greatest breadth of the shell is shifted from the middle more towards the front, but the Indian form is altogether broader, and not so much elongated as the English species.

There is no other species with which the present one could be more particularly compared.

2. LINGULA WARTHI, Waagen, n. sp.; Pl. LXXXVI, fig. 9.

This species is rather regularly elongate-oval, without a demarcated cardinal border. Besides this, it is characterised by a not very distinct radial plication.

I cannot decide whether the specimen from which this description is drawn up is a ventral or a dorsal valve.

The specimen is elongately oval, somewhat narrower in the apical than in the frontal region. The cardinal border is rather narrowly rounded, imperceptibly joining the lateral margins, which are diverging and nearly quite straight, only very little arched. The frontal margin is very flatly arched, but joins the lateral margins with a rather sudden bend. The whole valve is nearly quite flat, only very little vaulted. It is highest in the apical region. Not far from the apex a broad shallow sinus commences, and augmenting in breadth extends to not far from the frontal margin, but then disappears. The apex is rather obtuse, not prominent. On both sides of it thickened processes seem to extend interiorly, as can be seen through the transparent shell.

The surface of the shell is provided with few distant striæ of growth, which are crossed on the lateral parts of the shell by an irregular indistinct radial folding, producing an irregular reticulation of the shell surface.

Of the internal characters of this shell nothing is known to me.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	8	mm.
Greatest breadth of the shell (not far from the front)	6·5	„
Breadth in the cardinal region	4	„
Entire thickness of the shell	1	„

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by myself at Khewra above the salt-mines in the so-called "*Obolus* beds."

Remarks.—For a long time I was very much inclined to take this shell as the dorsal valve of the preceding species, but after a lengthened consideration I decided to consider it as a separate species. The chief reason which caused me to do so was the existence of a reticulation on the lateral parts of the present shell, a character which does not exist in *Ling. kiurensis.* It is not quite probable that the two valves of one and the same species should so far deviate from each other in the sculpturing, and, as the two specimens were not found in close proximity, to suggest their belonging to the same individual, I preferred to consider the two as different species.

I know of no European species with which the present one could be more closely compared.

PLATE LXXXII.

PRODUCTUS-LIMESTONE.

Figure 1. **Richthofenia lawrenciana**, Kon., sp., p. 736. Longitudinal section through a portion of the shell-substance of the larger valve, strongly enlarged, from the lower Productus-limestone of Amb; *i*, internal; *e*, external side; *l*, lower; *u*, upper part.

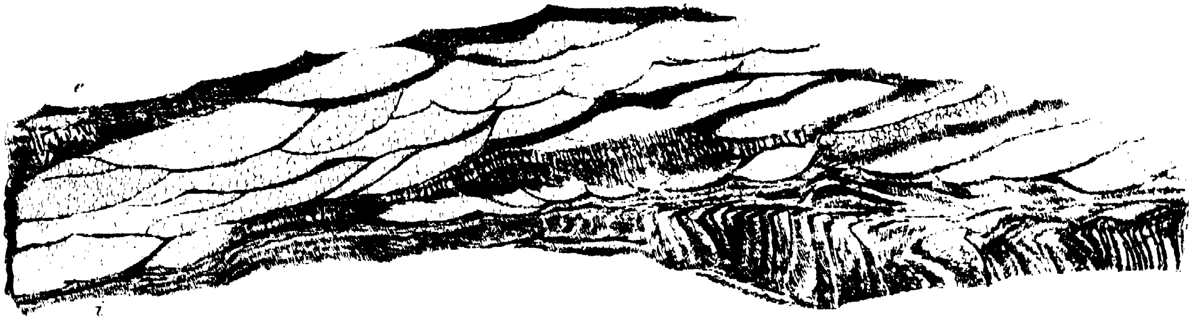
2. **Productus indicus**, Waagen, n. sp., p. 687. Microscopical section through the shell-substance (median layer), parallel to the surface, showing the terminations of the obliquely ascending canals.

3. **Derbyia grandis**, Waagen, n. gen. et sp., p. 597. 3*a*, longitudinal section through the shell-substance, vertical to the surface; *e*, external; *i*, internal side, the figure showing the external and the internal coating layer, and the median layer pierced by irregularly bending canals. 3*b*, section parallel to the surface, showing three of the radial ribs, with some rock-matter between; the latter is lined on both sides by the external coating layer. At both ends of the figure the median layer is exposed, showing the terminations of the canals. The canals are much finer than in *Productus*.

4. **Calceola sandalina**, Lam., from the devonian of the Eifel. Longitudinal section through a portion of the larger valve; *i*, internal; *e*, external side; fig. 4*a*, seen without transmitted light; 4*b*, with transmitted light.

5. **Radiolites**, sp., from the Gosau-formation of the Neue-Welt, near Vienna. Longitudinal section through a portion of the shell-substance of the larger valve; *i*, internal; *e*, external side.

1



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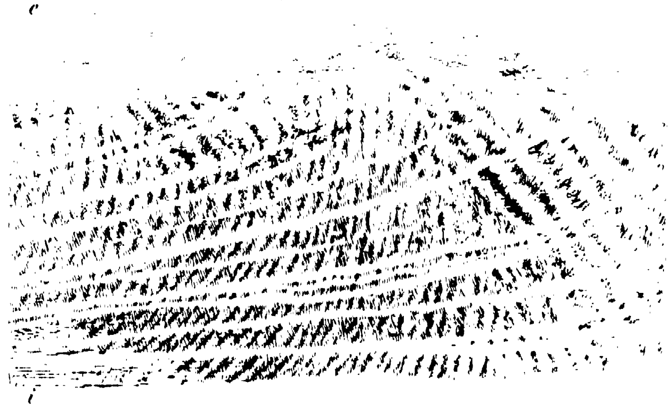

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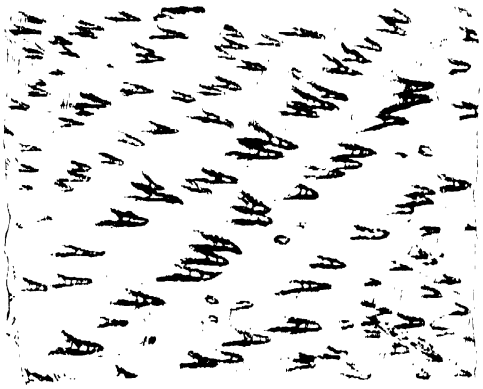

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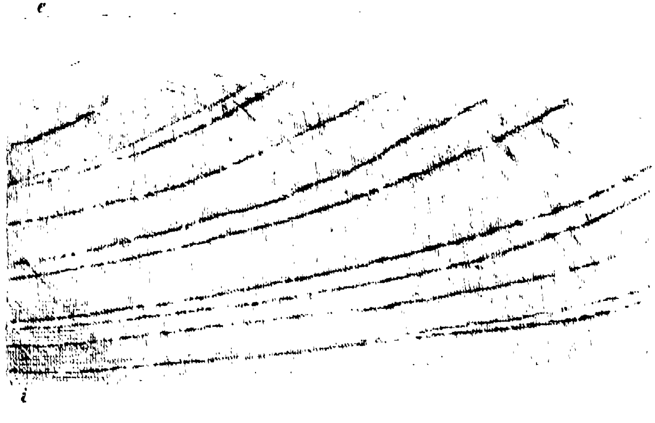

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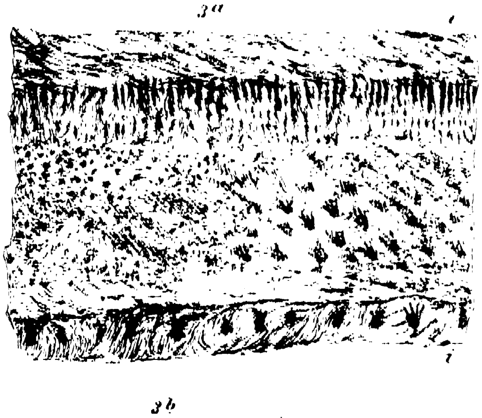

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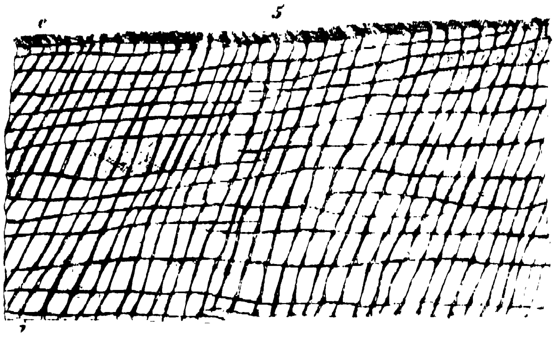

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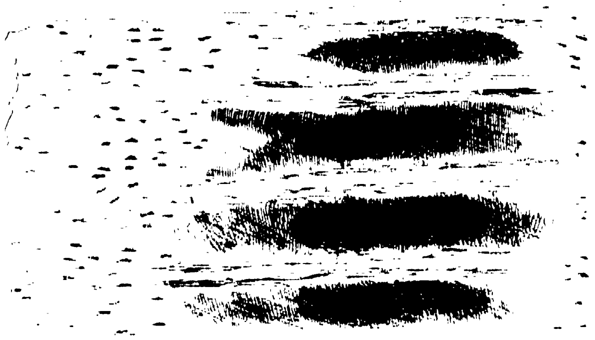


C. S. del et lith.

Lit. Keller, München print.

PLATE LXXXIIA.

PRODUCTUS-LIMESTONE.

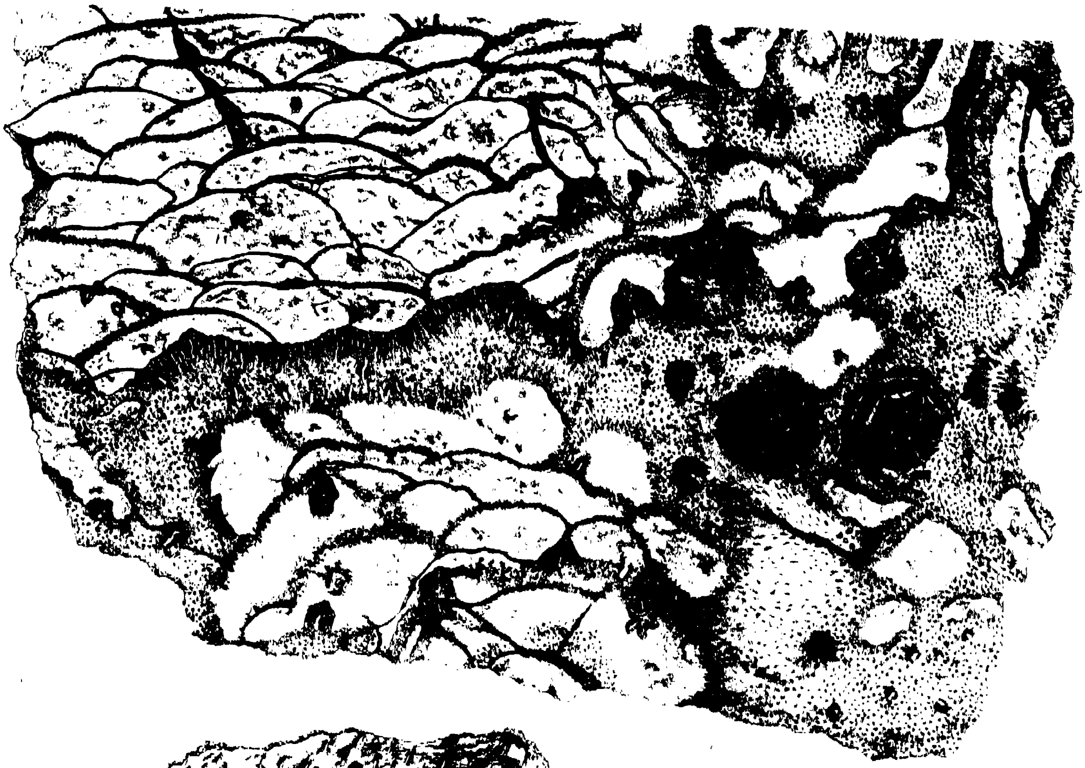
Figure 1. RICHTHOFENIA LAWRENCIANA, Kon., sp., p. 736. Portion of the shell-substance of the larger valve, section parallel to the surface, strongly enlarged. Owing to the unevenness of the shell, the cysts are partly exposed. In those places where the outer shell-layer is cut really parallel to the surface, the perforated granules, of two sizes, can be seen, whilst in other places, where the shell-lamella is cut obliquely, the canals in connection with these granules are distinguishable. The organs exhibiting a radial structure are probably sections of the polygonal straight tubes, figured Pl. LXXXIII, fig. 17.

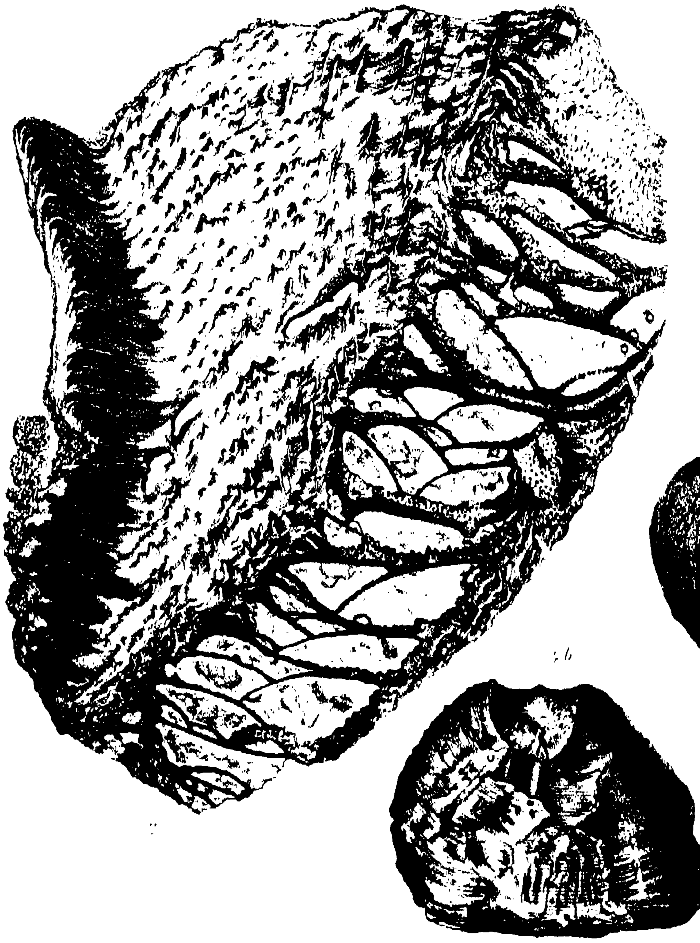
2. RICHTHOFENIA LAWRENCIANA, Kon., sp., p. 736. Portion of the shell-substance of the larger valve; vertical section through the thickened shell part at both ends of the hinge-line, including the upper margin of the shell, strongly enlarged. To the left, above, is the thickened shell-margin, which bears the pallial impression; below are the entrances of some of the hollow tubes, which appear further down on the shell as root-like processes. The middle part of the figure is occupied by a greatly thickened compact shell-mass, then comes the cystiferous layer, and at last the outer coating layer.

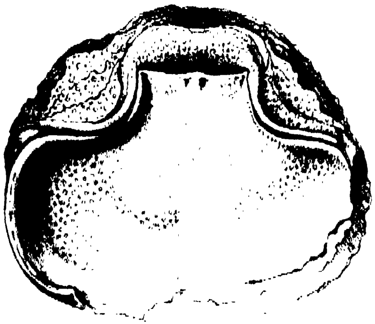
3. RICHTHOFENIA LAWRENCIANA, Kon., sp. Dorsal valve and surrounding parts enlarged twice, to show the granulations with which all is covered; from the lower Productus-limestone of Amb.

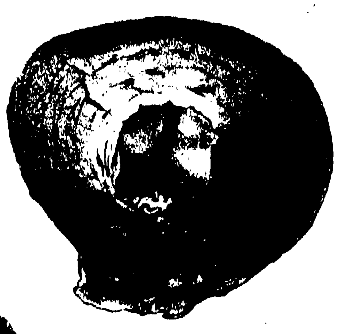
4. RICHTHOFENIA SINENSIS, Waagen, n. sp., p. 742. Specimen from the upper-carboniferous beds of Lo-ping in China (original in the Berlin Museum); 4*a*, from below, to show the form of the partition; 4*b*, view from the hinge-line, the partition above and parts of the area and pseudodeltidium exposed; 4*c*, cardinal part of the smaller valve of the same specimen. All three figures enlarged twice.

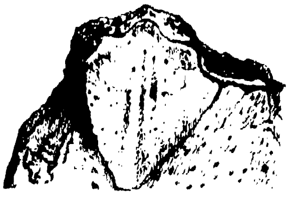
SALT-RANGE FOSSILS.











A. Swoboda del et lith.

Th. Bannwarth pr.

PLATE LXXXIII.

PRODUCTUS-LIMESTONE.

Richthofenia lawrenciana, Kon., sp., p. 736.

Figure 1. Silicified specimen from the upper region of the middle Productus-limestone of Musakheyl: 1*a*, view of the animal-chamber straight from above; 1*b*, the same slightly oblique from the front; 1*c*, interior side of the smaller valve of the same specimen.

2. Specimen from the lower Productus-limestone of Amb: view from above, showing the external side of the smaller valve well preserved.

3. Specimen from the lower Productus-limestone of Amb, showing a longitudinal striation on the outer surface of the larger valve.

4. Large specimen from the middle Productus-limestone of the Chittawán lateral view.

5. Small specimen from the lowest beds of the middle Productus-limestone of Katta: large valve seen from below, showing the place of attachment.

6. Specimen from the lower Productus-limestone of Amb, cut through from the hinge-line to the front.

7. Specimen from the coral-beds of the middle Productus-limestone, showing a natural section through the larger valve parallel to the hinge-line, and not far from that line.

8. Specimen from the lower Productus-limestone of Amb, cut through parallel to the hinge-line, but at a considerable distance from that line.

9 & 10. Fragmentary specimen from the middle Productus-limestone of the Chittawán; 9, natural transverse section through the lower part of the animal-chamber; 10, rather oblique section immediately below the animal-chamber.

11. Specimen from the lower Productus-limestone of Amb: transverse section through the lower part of the larger valve.

12. Fragmentary large valve of a specimen from the middle Productus-limestone of the Chittawán: view from below, at a fracture exposing one of the partitions.

13. Fragmentary specimen from the same bed and locality as the preceding: view from below, showing irregular partitions.

14. Specimen from the middle Productus-limestone of Musakheyl: impression of the interior side of the smaller valve.

15. Partial internal cast of a specimen from the middle Productus-limestone of Musakheyl: 15*a*, view of the area and pseudodeltidium; 15*b*, view from above, showing the impression of the smaller valve.

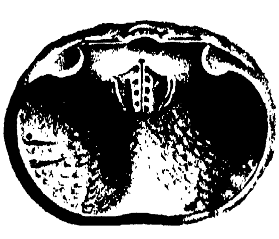
16. Fragmentary specimen from the middle Productus-limestone near Khewra: view, from the hinge-line, the outer coating layer of the shell being removed, and thus the cystiferous layer exposed to view; 16*a*, natural size, 16*b*, the same enlarged.

17. Weathered part of the shell of a specimen from the upper Productus-limestone (Cephalopoda bed) of Jabi, showing the straight polygonal tubes, extending in an obliquely ascending direction through the cystiferous shell-layer enlarged about four times.

18. Enlarged part of the surface of the specimen represented in fig. 3.

19. Enlarged representation of the punctation of the outer shell-layer of a specimen from Musakheyl.

Geol. Surv. of India. SALT-RANGE FOSSILS. Pl. LXXXIII.



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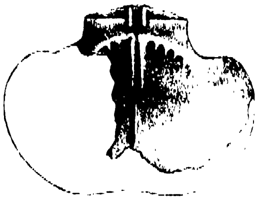

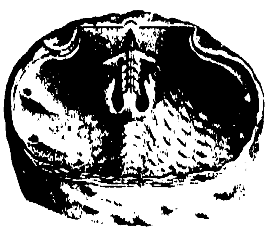

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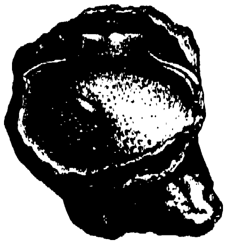

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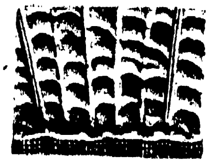

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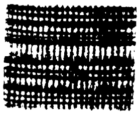

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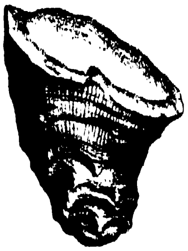

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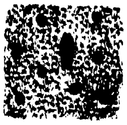

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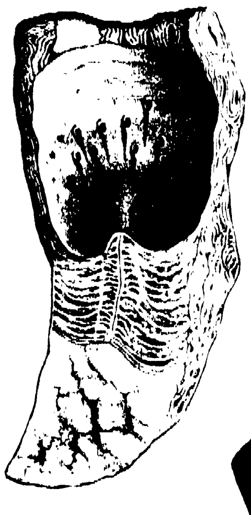

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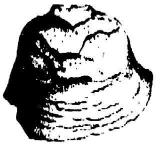

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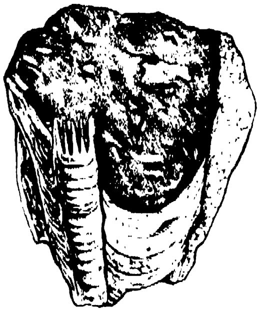

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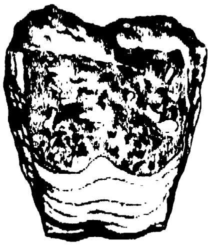

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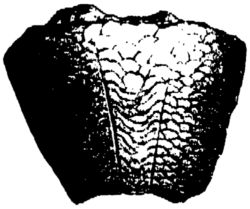

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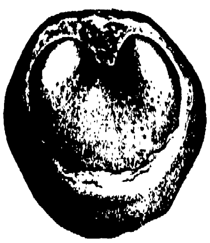

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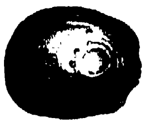

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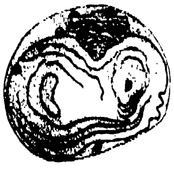

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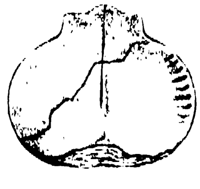

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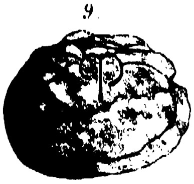

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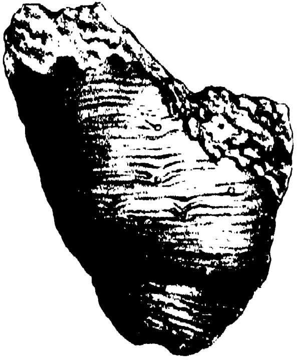

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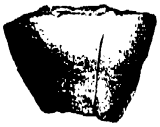

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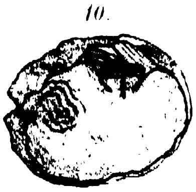

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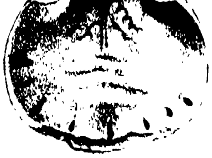

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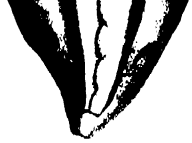

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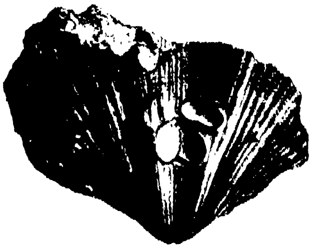
PLATE LXXXIV.

PRODUCTUS-LIMESTONE.

Figures 1—2. **CARDINOCRANIA INDICA**, Waagen, n. gen. et sp., p. 746. Fig. 1, a ventral valve of *Spirifer musakhelensis*, Dav., with two specimens of the ventral valve of *Cardinocrania indica* on it, from the middle Productus-limestone of Morah; 1*a*, natural size; 1*b*, the same strongly enlarged. Fig. 2, a fragment of *Stenopora*, with a specimen of the ventral valve of *Cardinocrania indica* on it, from the *Cephalopoda*-bed of the upper Productus-limestone of Jabi; 2*a*, natural size; 2*b*, the same strongly enlarged.

3—8. **NEOBOLUS WARTHI**, Waagen, n. gen. et sp., p. 758. Several specimens from the "*Obolus* beds" of Khewra: Fig. 3, ventral valve, external side; 3*a*, natural size; 3*b*, the same enlarged. Fig. 4, ventral valve, external side, much deformed by pressure, natural size. Fig. 5, dorsal valve, external side; 5*a*, natural size; 5*b*, same enlarged. Fig. 6, ventral valve, internal side, strongly enlarged. Fig. 7, dorsal valve, internal side, strongly enlarged. Fig. 8, piece of rock, containing four dorsal and one ventral valve of the species.

SALT-RANGE FOSSILS.



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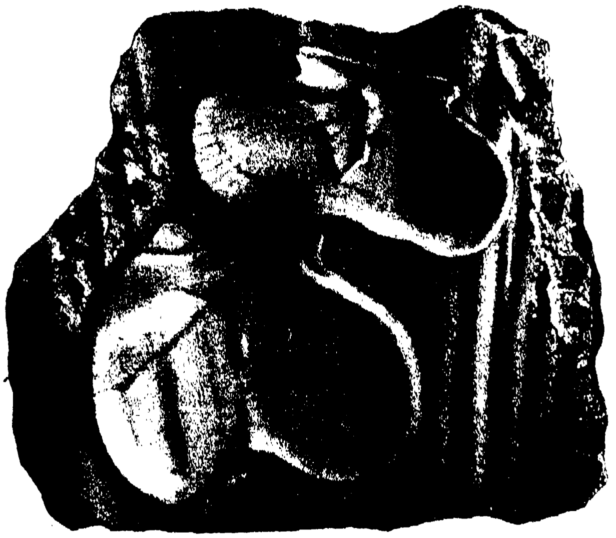
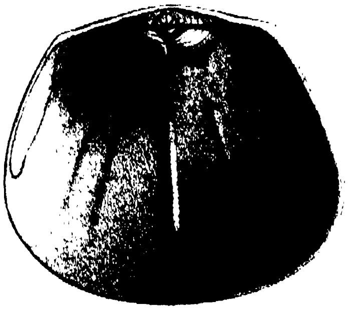


1b.

2a



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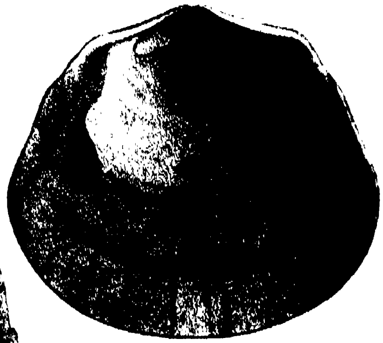

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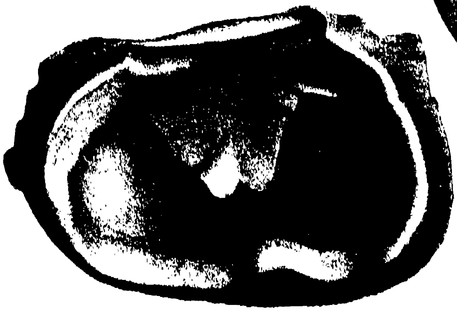

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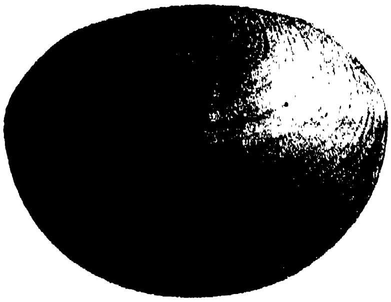

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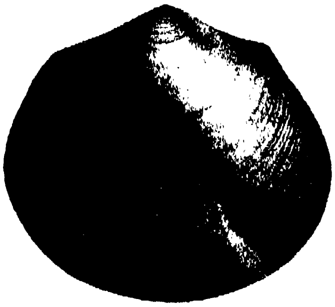
4.



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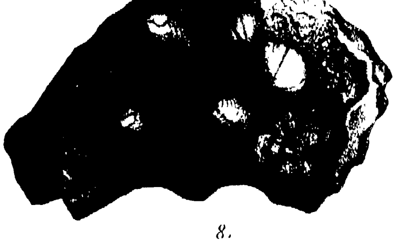

8.

5a.

3a

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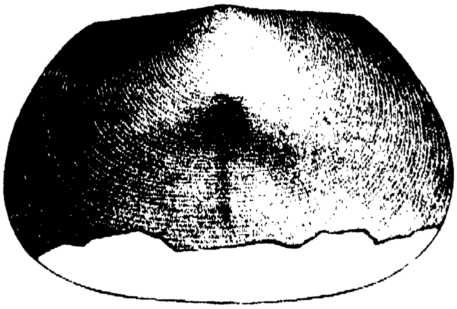
PLATE LXXXV.

PRODUCTUS-LIMESTONE.

Figures 1—2. **Neobolus wynnei**, Waagen, n. gen. et sp., p. 759. Fig. 1, specimen of the ventral valve from the *Obolus* beds, of Khewra, external view; 1*a*, natural size; 1*b*, the same enlarged; 1*c*, part of the surface yet more strongly enlarged. Fig. 2, specimen of the dorsal valve from the "*Obolus* beds" of Jutána; 2*a*, natural size; 2*b*, the same enlarged; 2*c*, part of the surface yet more strongly enlarged.

3—6. **Davidsonella linguloides**, Waagen, n. gen. et sp., p. 764. Four specimens from the "*Obolus* beds" of Jutána: Fig. 3, ventral valve, with partly preserved shell, external view; 3*a*, natural size; 3*b*, the same strongly enlarged. Fig. 4, dorsal valve, somewhat broken at the margin to the right, external view; 4*a*, natural size; 4*b*, the same strongly enlarged. Fig. 5, dorsal valve, internal side, strongly enlarged. Fig. 6, ventral valve, internal side, strongly enlarged (the lateral impressions are much too strongly expressed and too distinctly circumscribed in this figure; they are more of the character as indicated on the impression fig. 3*b*).

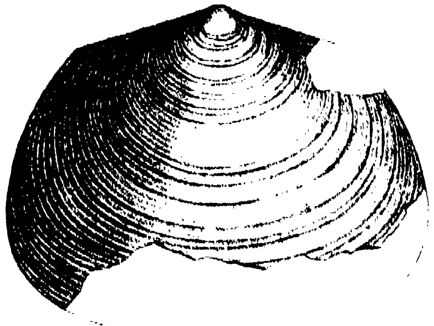
2b



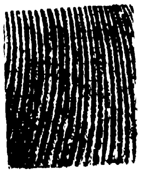
2a

1a

1b



2c



1c

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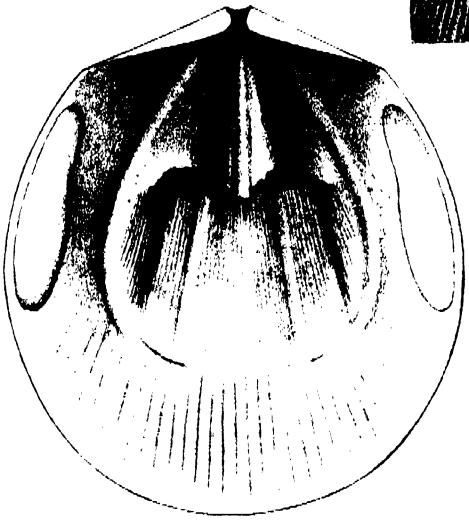

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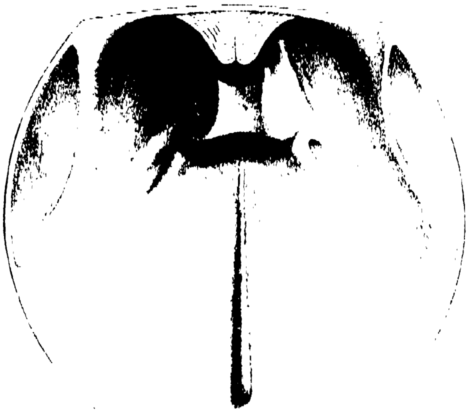

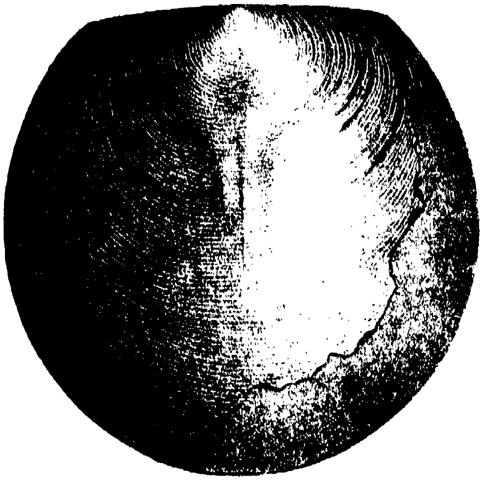

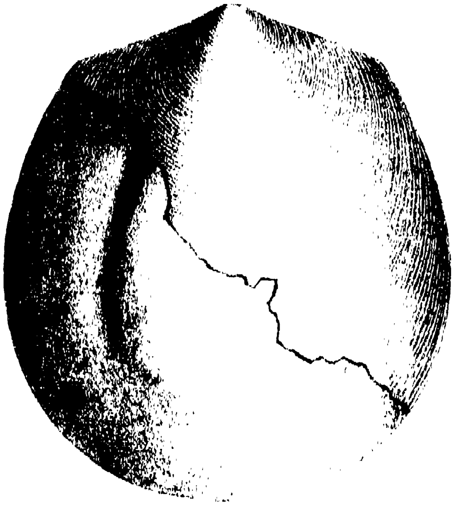

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PLATE LXXXVI.

PRODUCTUS-LIMESTONE.

Figure 1. **Davidsonella squama**, Waagen, n. gen. et sp., p. 766. Well-preserved specimen of the ventral valve from the "*Obolus* beds" of Jutána: 1*a*, natural size; 1*b*, the same strongly enlarged.

2—4. **Schizopholis rugosa**, Waagen, n. gen. et sp., p. 753. Three specimens from the "*Obolus* beds" of Khewra. Fig. 2, dorsal valve, external side; 2*a*, natural size; 2*b*, the same strongly enlarged. Fig. 3, dorsal valve of another specimen, external view; 3*a*, natural size; 3*b*, the same strongly enlarged; the foramen at the top is only caused by the apex being broken. Fig. 4, ventral valve, external size; 4*a*, natural size; 4*b*, the same enlarged; 4*c*, lateral view, enlarged; 4*d*, view of the area, enlarged. The form of the apex is not quite certain, as it is much deformed by pressure.

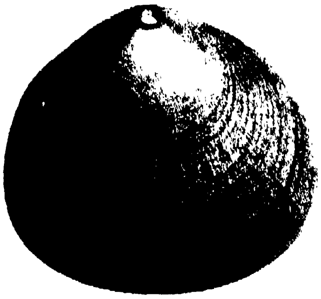
5—7. **Discinolepis granulata**, Waagen, n. gen. et sp., p. 750. Fig. 5, specimen of the ventral valve from the "*Obolus* beds" of Khewra. External view, 5*a*, natural size; 5*b*, the same enlarged. Fig. 6, specimen of the ventral valve from the "*Obolus* beds" of Jutána, external view; 6*a*, natural size; 6*b*, the same enlarged. Fig. 7, fragment of a dorsal valve, probably belonging to this species, from the "*Obolus* beds" of Khewra, strongly enlarged.

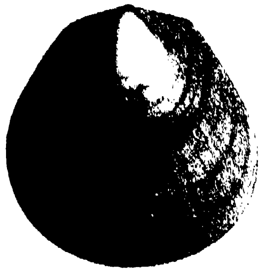
8. **Lingula (?) kiurensis**, Waagen, n. sp., p. 768. Specimen from the "*Obolus* beds" of Khewra: 8*a*, natural size; 8*b*, the same enlarged.

9. **Lingula (?) warthi**, Waagen, n. sp., p. 769. Specimen from the "*Obolus* beds" of Khewra; 9*a*, natural size, 9*b*, the same enlarged.

SALT-RANGE FOSSILS.

Pl. LXXXVI.





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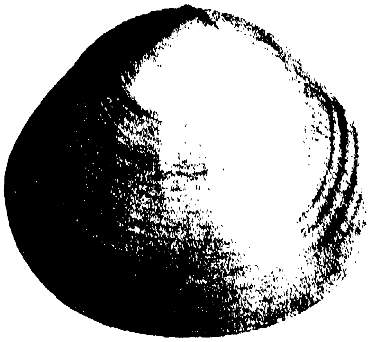

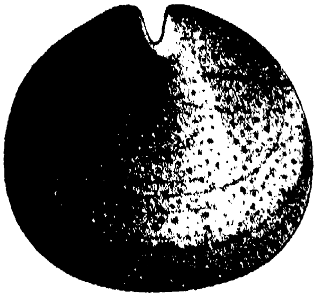

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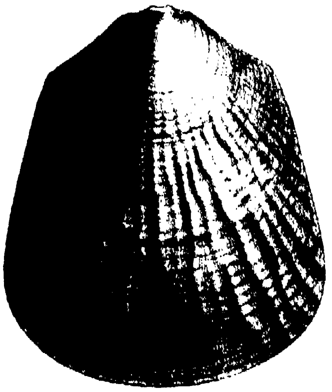

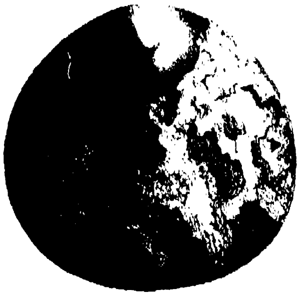

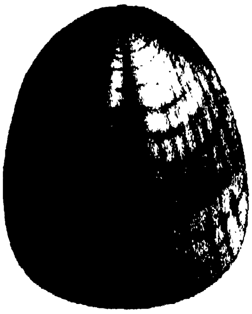

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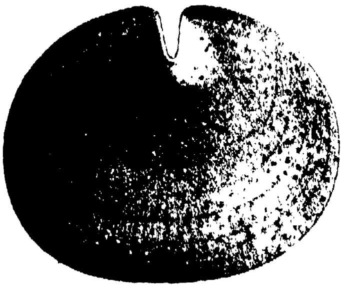

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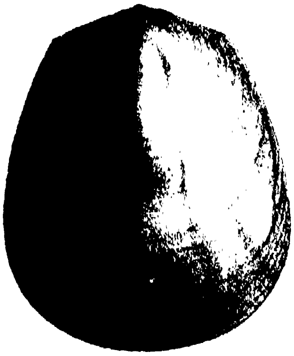

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